New Nouveau
Brunswick

92-06522/

Open File Report 92-5

QUATERNARY GEOLOGY AND DISPERSAL PATTERNS OF THE CANTERBURY AREA, NEW BRUNSWICK

Solweig A. Balzer

Natural Resources and Energy

Mineral Resources

ISSN 1183-5508

Price $6.50

Open File Report 92-5

Quaternary Geology and Dispersal Patterns of the Canterbury Area, New Brunswick

This report has been reprinted by:

Mineral Resources
Department of Natural Resources and Energy
Province of New Brunswick

Hon. Alan R. Graham
Minister of Natural Resources and Energy

Hon. Doug Tyler
Minister of State for Mines and Energy

May, 1992

New Nouveau
Brunswick

Open File Report 92-5

Quaternary Geology and Dispersal Patterns of the Canterbury area, New Brunswick

Solweig A. Balzer

Natural Resources and Energy

Mineral Resources

May, 1992

This report should be referenced in the following manner:

BALZER, S.A. 1992. Quaternary geology and dispersal patterns of the Canterbury area, New Brunswick. New Brunswick Department of Natural Resources and Energy, Mineral Resources, Open File Report 92-5, 192 p.

MINERAL RESOURCES
DEPARTMENT OF NATURAL RESOURCES AND ENERGY
NEW BRUNSWICK

DATE April 27, 1992

AUTHOR Solweig Anita Balzer

TITLE Quaternary Geology and Dispersal Patterns of the Canterbury Area, New Brunswick

Permission is herewith granted to the Mineral Resources Division of the New Brunswick Department of Natural Resources and Energy, or its successors, to copy the above titled thesis, and to release it for sale as an Open File Report.

Signature of Author

THE AUTHOR RESERVES OTHER PUBLICATION RIGHTS, AND NEITHER THE THESIS NOR EXTENSIVE EXTRACTS FROM IT MAY BE PRINTED OR OTHERWISE REPRODUCED WITHOUT THE AUTHOR'S WRITTEN PERMISSION.

THE AUTHOR ATTESTS THAT PERMISSION HAS BEEN OBTAINED FOR THE USE OF ANY COPYRIGHTED MATERIAL APPEARING IN THIS THESIS (OTHER THAN BRIEF EXCERPTS REQUIRING ONLY PROPER ACKNOWLEDGMENT IN SCHOLARLY WRITING) AND THAT ALL SUCH USE IS CLEARLY ACKNOWLEDGED.

QUATERNARY GEOLOGY AND DISPERSAL PATTERNS OF THE CANTERBURY AREA, NEW BRUNSWICK

by

Solweig Anita Balzer

B.Sc., University of Waterloo, 1989

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

Master of Science

in the Department of

Geology

This thesis is accepted.

.....

Dean of Graduate Studies and Research

THE UNIVERSITY OF NEW BRUNSWICK

April, 1992

© Solweig A. Balzer, 1992

ABSTRACT

The surficial geology of the Canterbury map area (N.T.S. 21 G/14) in southwestern New Brunswick is the result of glaciation in a maritime environment during the Late Wisconsinan. Rapid deglaciation is supported by the lack of end moraines and widespread stagnation moraine.

A total of 273 samples of Late Wisconsinan sediments were collected on a 2 km^2 grid during surficial mapping for the New Brunswick Department of Natural Resources and Energy. The samples were analyzed for granulometric, geochemical and lithological components and results investigated by areal dispersal plots.

Dispersal patterns are more distinctive for clasts than they are for geochemical or granulometric components. Southeastward and southward trending dispersal trains can be traced up to 10 kilometres for aplite, volcanic and granite clasts. Geochemical dispersion patterns are localized (<5 kilometres in length), with values barely exceeding background limits. Well-defined geochemical anomalies (e.g. Au, As, Ag, Sb) can be traced to known mineral occurrences.

Directional indicators and dispersal patterns suggest two styles of glaciation occurred in the study area. Ice-streaming occupied the Saint John River Valley in the early phase of glaciation and preceded the advance of a regional and thicker ice sheet over the higher topographic regions. The southeast and southwards ice-flow patterns are conformable to ice originating from the North Maine-Notre Dame Ice Divide.

The homogeneity of the granulometric parameters and the gradual changes in lithology of till between sample sites suggest that the surficial deposits are facies of a single ice-flow event. Till can be subdivided into four lithofacies for mapping and descriptive purposes. These observations support a model for matrix and lithologic diffusion of glacial load, in response to incorporation of local bedrock, as the glacier flowed south and southeastward across the area.

Areas of higher elevation underwent rapid deglaciation resulting in the deposition of stagnation moraine across most of the study area. Meltwater channels were catastrophic and limited in duration, forming boulder lags in some of the stream valleys. Ice during the final stages of deglaciation was restricted to lobes occupying the Saint John River Valley.

RÉSUMÉ

La géologie des formations superficielles de la région cartographique de Canterbury (SNRC 21 G/14) dans le sud-ouest du Nouveau-Brunswick est le résultat d'une glaciation survenue dans un

environnement maritime au cours du Wisconsinien supérieur. La déglaciation rapide est confirmée par l'absence de moraines frontales et la présence d'une moraine de stagnation étendue.

Au total, 273 échantillons de sédiments du Wisconsinien supérieur ont été prélevés sur un quadrat de 2 km^2 pendant les travaux de cartographie superficielle réalisés à l'intention du ministère des Ressources naturelles et de l'Énergie du Nouveau-Brunswick. On a analysé les échantillons pour déterminer leurs composants granulométriques, géochimiques et lithologiques, et on a étudié les résultats à l'aide de levés aériens des dispersions.

Les configurations des dispersions sont plus distinctives dans le cas des clastes qu'elles ne le sont dans le cas des composants géochimiques ou granulométriques. On a pu relever des alignements de dispersions orientés vers le sud-est et le sud sur une distance atteignant jusqu'à 10 km dans le cas des clastes aplitiques, volcaniques et granitiques. Les configurations des dispersions géochimiques restent localisées (<5 km de longueur), avec des valeurs dépassant à peine les limites de référence. Des anomalies bien définies (p. ex. Au, As, Ag, Sb) permettent de relever des venues minérales connues.

Les indicateurs de direction et les configurations des dispersions laissent supposer que deux types de glaciations sont survenues dans la région étudiée. Un courant glaciaire a occupé la vallée du fleuve Saint-Jean au cours de la première phase de glaciation et il a précédé l'avance d'une nappe glaciaire régionale plus épaisse par-dessus les régions topographiques plus élevées. Les configurations de l'écoulement glaciaire vers le sud-est et le sud sont compatibles avec les glaces provenant de la ligne de partage nord du Maine/Notre-Dame.

L'homogénéité des paramètres granulométriques et les modifications graduelles de la lithologie de la moraine située entre les sites étudiés laissent supposer que les gisements superficiels constituent les faciès d'une activité d'écoulement glaciaire unique. On peut subdiviser la moraine en quatre lithofaciès aux fins de cartographie et de description. Ces observations viennent étayer un modèle de diffusion matricielle et lithologique de la charge glaciaire, en réponse à l'incorporation d'un substrat rocheux local, au moment où le glacier s'est déplacé vers le sud et le sud-est à travers la région.

Les régions d'élévation supérieure ont subi une déglaciation rapide qui a provoqué le dépôt d'une moraine de stagnation à travers la majeure partie de la région étudiée. Les chenaux d'eau de fonte ont été catastrophiques et de courte durée : ils ont formé des dépôts résiduels de roches dans certaines des vallées fluviatiles. Les glaces se sont limitées à des lobes de la vallée du fleuve Saint-Jean pendant les phases finales de la déglaciation.

TABLE OF CONTENTS

ABSTRACT/RÉSUMÉ ii

TABLE OF CONTENTS iv

LIST OF FIGURES vii

LIST OF TABLES ix

ACKNOWLEDGEMENTS x

DEDICATION xi

CHAPTER 1.0 : INTRODUCTION 1

1.1 Purpose and Scope of Investigation 1

1.2 Previous work 4

1.2.1 Surficial Studies 5

1.2.2 Glacial History 7

CHAPTER 2.0 : FIELD AND LABORATORY METHODS 12

CHAPTER 3.0 : LOCATION AND BEDROCK GEOLOGY 17

3.1 Location and Access 17

3.2 Physiography and Drainage 17

3.3 Bedrock Geology 23

3.3.1 Mineralization 32

CHAPTER 4.0 : SURFICIAL GEOLOGICAL MAPPING 33

4.1 Morainal Deposits 34

4.1.1 Pokiok Till 34

4.1.2 Dorrington Hill Till 35

4.1.3 Hammond Brook Till 36

4.1.4 Lake George Till 36

4.2 Glaciofluvial Deposits 37

4.3 Organics 39

4.4 Bedrock 39

4.5 Erosional Indicators 40

CHAPTER 5.0 : RESULTS OF LITHOLOGICAL, GRANULOMETRIC AND GEOCHEMICAL ANALYSES 45

5.1 Pebble Lithology 45

5.1.1 Western and Eastern Sedimentary Rocks ... 45

5.1.2 Volcanics 46

5.1.3 Granites 46

5.1.4 Felsic Dykes 47

5.1.5 Mafic Intrusives 47

5.1.6 Purple Slates 54

5.2 Matrix Lithology 54

5.3 Granulometric Data 55

5.3.1 Sand/silt/clay Ratios 60

5.3.2 Graphic Statistics 61

5.4 Geochemistry 61

CHAPTER 6.0 : DISCUSSION 79

6.1 Ice-Flow Patterns 79

6.2 Dispersal Patterns 81

6.2.1 Clast Dispersal Patterns 82

6.2.2 Matrix Dispersal Patterns 84

6.2.3 Significance 87

6.3 Style of Glaciation 88

6.4 Style of Deglaciation 92

CHAPTER 7.0 : CONCLUSIONS 94

REFERENCES 97

APPENDIX I - Site Locations 106

APPENDIX II - Pebble and Matrix Lithology 117

APPENDIX III - Granulometric Analyses 135

APPENDIX IV - Geochemical Analyses 148

LIST OF FIGURES

Brackets () indicate shortened figure captions.

Figure 1.1 Location of study area..... 3

Figure 2.1 (Example of sample grid used in the study area.)..... 15

Figure 3.1 Location map for the study area..... 19

Figure 3.2 Topography of the study area 21

Figure 3.3 Drainage pattern of the study area..... 25

Figure 3.4 (Tectonostratigraphic zones of New Brunswick.)..... 27

Figure 3.5 (Bedrock geology of the study area.)..... 29

Figure 4.1 Glacial erosional ice-flow indicators in the study area..... 43

Figure 5.1 (Dispersal pattern of volcanic clasts.)..... 49

Figure 5.2 (Dispersal pattern of granite clasts.)..... 51

Figure 5.3 (Dispersal pattern of aplite clasts)..... 53

Figure 5.4 (Dispersal pattern of mafic intrusive clasts.)..... 57

Figure 5.5 (Dispersal pattern of granite in the matrix.)..... 59

Figure 5.6 Sand/silt/clay ratios of the tills and glaciofluvial sediments..... 63

Figure 5.7 (Dispersal of sand in matrices of samples)... 65

Figure 5.8 (Dispersal pattern of clay in sample matrices.)..... 67
Figure 5.9 (Gold dispersion in the study area.)..... 71
Figure 5.10 (Arsenic dispersion in the study area.)..... 73
Figure 5.11 (Antimony dispersion in the study area.)..... 75
Figure 5.12 (Silver dispersion in the study area.)..... 77

Map 92-68 Surficial geology of the Canterbury map area (21G/14), New Brunswick (In map pocket)

LIST OF TABLES

Table 5.1 Background limits for specific elements..... 68

Table 6.1 Geochemical anomaly classification..... 83

Table IV.1 Accuracy of I.N.A.A..... 149

Table IV.2 Precision of I.N.A.A..... 150

Table IV.3 Precision of A.A.S. Analysis..... 152

ACKNOWLEDGEMENTS

This thesis would never have been completed without the help and support of several people. I would like to thank my supervising committee, Dr. B.E. Broster and Dr. R.F. Miller, for all the helpful hints and for keeping me in line and on topic. Thanks to Dr K.B.S. Burke for critically reviewing my thesis.

Thanks to: the New Brunswick Department of Natural Resources and Energy in Fredericton for logistical support; A.A. Seaman for supervision, and help with sampling; A. Pronk and the D.N.R. geochemical lab for sample preparation, geochemical data, and the use of your lab for hydrometer tests; the chemical engineering lab at U.N.B. for the use of lab space and equipment; the Rangers in the Canterbury office; and, my field assistants (Norah Brown, Garrett Bell, and Janice Comeau) for help and company during field season. Help on all those "little things" by the secretaries (Pamela Racette, Diane Tabor, Sherri Townsend and Debbie Basque) and the technicians (Bob McCulloch, David Pirie, Ancel Murphy and Angel Gomez) was greatly appreciated.

To Robin Wyllie and Dave Huntley, thanks for the suggestions, corrections, and especially, the good times. To Scott, Lori, Bruno, Adrian, Pat, Cuneyt, Suporn, Wattana, Dave K., Shoufa, and Bryan, thanks for the dinner parties, nights at the Rogue, and the field trips.

DEDICATION

This thesis is dedicated to Robin, and the Balzer, Wyllie, and Fay families, for all the support and encouragement they've given me in everything I've done over the years.

CHAPTER 1

INTRODUCTION

The Quaternary glacial history of New Brunswick has been a topic of contention since the late 1800's. New Brunswick's geographical location, a maritime environment situated in the core of the Appalachians, imposes conditions on the style of glaciation. Such an environment should have favoured glaciation by fast-moving, warm-based, sub-alpine glaciers (Sugden and John, 1976), while a few hundred kilometres to the north, glaciation was the product of continental (e.g. Laurentide) ice sheets (Grant, 1989).

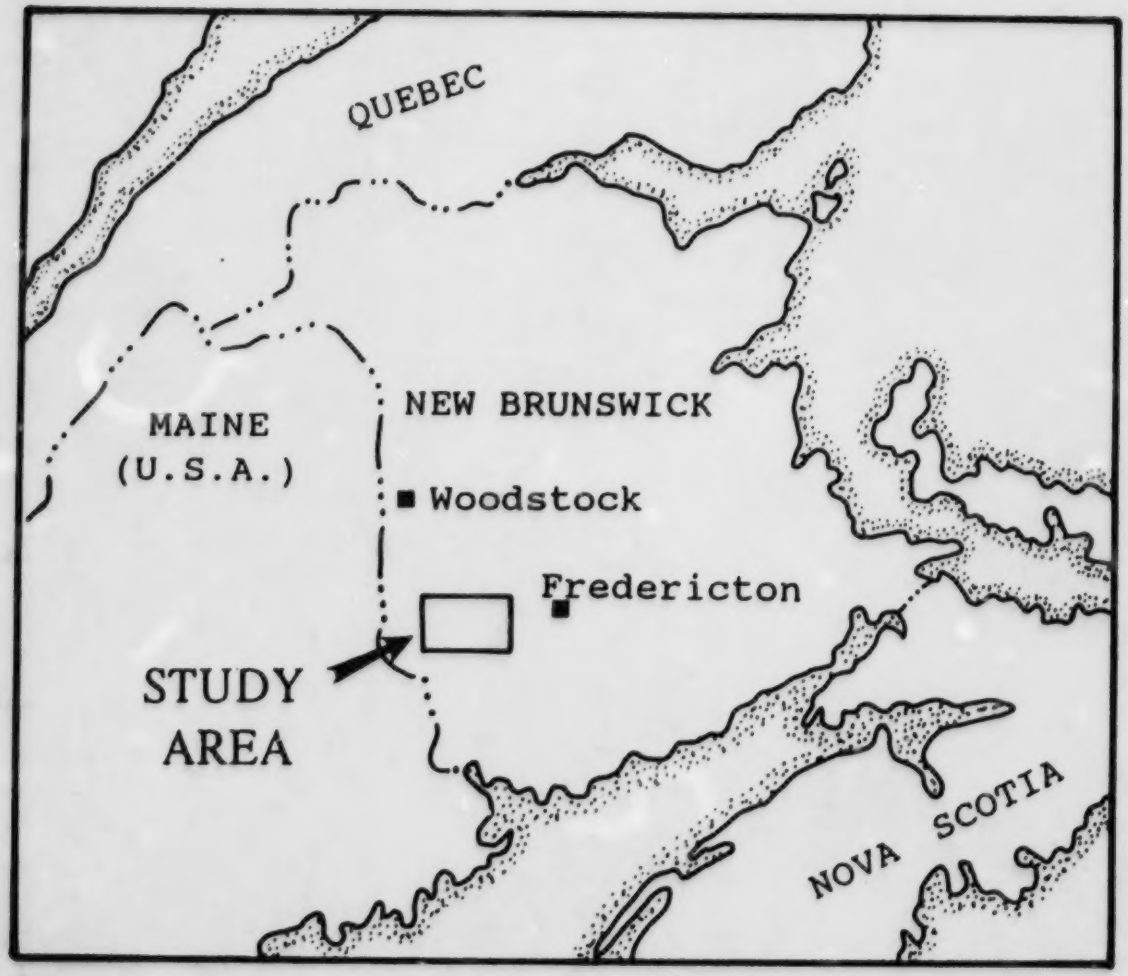
Good stratigraphic and chronological correlations are lacking in New Brunswick for the Wisconsinan. Exposures of multiple tills with datable layers are rare. Ice flow directions are complex and their relationship to Laurentide Ice and local ice caps in the Atlantic region is uncertain.

1.1 Purpose and Scope of Investigation

The purpose of this project was three-fold. The primary objective of the study was to describe the nature and style of glacial advance and retreat in the Canterbury area (Figure 1.1) and propose a relative chronology of these events.

The secondary objective was to investigate the limits and style of glacial dispersal in the study area, as indicated by lithological and geochemical components of till and their ability to reflect bedrock sources.

Figure 1.1 Location of study area.


QUEBEC
NEW BRUNSWICK
MAINE
(U.S.A.)
Woodstock
Fredericton
STUDY
AREA
NOVA SCOTIA

The third objective was to study ice flow directions in the Canterbury map area and to check whether they support suspected northward flow in New Brunswick (Seaman, 1989, 1991) and Nova Scotia (Stea and Mott, 1990).

These objectives were accomplished by the collection of samples on a 2 km grid while mapping the surficial geology at a scale of 1:50 000.

1.2 Previous Work

The lack of stratigraphic exposures, along with a high water table and dense vegetation, make this area relatively inaccessible and difficult to study in detail. Also, previously mapped stratigraphic sections in the Saint John River valley are submerged in the headpond of the Mactaquac Dam.

Previous surficial geological studies of the area have focused on regional mapping. Information was generalized in an effort to fit into a broader historical and stratigraphic framework. Recent detailed studies have been restricted to particular aspects of the area (aggregate and peat resources, striae trends and glaciotectonics).

Geochemical studies of tills have been undertaken elsewhere in New Brunswick. Most of this work has been through Mineral Development Agreement (M.D.A.) projects, the Geological Survey of Canada, and the New Brunswick Department of Natural Resources and Energy (N.B.D.N.R.E.).

1.2.1 Surficial Studies

The earliest work on the Quaternary geology of southwestern New Brunswick was in the late 19th century by Matthew (1879) and Chalmers (1885, 1886, 1902). Most of the surficial maps of New Brunswick were compiled by Chalmers during this period, who described units based on their extent and general physiographic characteristics. From observations of striae and other glacial erosional features, Chalmers (ibid.) indicated a strong south to southeast ice flow direction. Multiple striae directions were attributed to glacier flow at various stages of development or stagnation, and topographic control (Chalmers, ibid.).

In 1962, Lee mapped a 6 by 24 mile corridor centred on the Saint John River Valley and Nackawic. He noted exposures of 150 feet of glacial material with basal till exceeding 50 feet thick at some sites. Surficial deposits adjacent to the valley were mapped and described in generalized terms with little differentiation. Measurements taken from striae and till fabrics were interpreted as indicators of a strong south-southeasterly flow direction (Lee, 1962).

Reconnaissance mapping in southwestern New Brunswick was conducted at a 1:250 000 scale by Gadd (1973). His report describes general characteristics of the surficial units and gave an interpretation of the glacial history of southern New Brunswick. The surficial geology of the study area, located in the northernmost section of Gadd's map area (12-1971), was

based on work by Lee (1962), with revisions of some of the surficial units.

Overburden drilling using a rotasonic drill was performed by the Geological Survey of Canada (G.S.C.), during the winter of 1986-1987 along the Saint John River (Lamothe, 1990). Many of the boreholes intercepted diamicton units, overlain by thick sequences of glaciofluvial sediments.

Grant (1989), in his summary of glacial activity in the Atlantic Appalachian region of Canada, used Rampton et al. (1984) as the basis for the description of the Quaternary geology of New Brunswick. In his summary he describes and compares the concepts of the style of glaciation in New Brunswick (ie. cold- or warm-based) as related to the occurrences of deeply weathered bedrock.

Glaciotectonic activity is documented in the Charlie Lake area by Broster and Seaman (1991). They studied the occurrence of imbricated rafts of weathered bedrock beneath a granitic till. Rafts were separated by glacigenic fault planes, some of which were defined by thin lenses of till. Imbrication of the rafts is upglacier and the proposed southeastward movement direction is conformable to local striae and till fabric directions (Broster and Seaman, ibid.). Its preservation is indicative of local subglacial freezing. Glacigenic rafting in the area may be more widespread, in response to certain subglacial conditions (Broster and Seaman (ibid.). However, no

additional evidence of subglacial freezing was found during the present study.

Aggregate studies for the Canterbury map area were completed by Geocon, Ltd. for N.B.D.N.R.E. in 1982 (Hunter and Lavergne, 1982). This study was part of a survey by the New Brunswick government to evaluate the distribution, extent, thickness and quality of aggregate deposits in the province.

Peat bogs in the study area were mapped to evaluate peat resources in New Brunswick (Keys and Henderson, 1983). The study dealt mainly with the larger peat bogs in the Canterbury area. Peat bogs were evaluated for extent, type, and resource potential.

Seaman (1989, 1991) compiled all documented information on striae trends in New Brunswick. Striae measurements, taken by Seaman (1991) in the study area and the surrounding vicinity, indicate strong ice flow directions ranging from 088° to 225°. Possible northward flow has been suggested by Seaman (ibid.), northeast and south of the study area.

1.2.2 Glacial History

The glacial history of New Brunswick during the Quaternary is enigmatic. Evidence of pre-Late Wisconsinan glacial activity is rare and questionable. The lack of datable material and poor exposures in mainland New Brunswick are major handicaps to stratigraphic correlations.

Several authors have attempted to explain the surficial geology of New Brunswick by means of a glacial historic framework. For example, ice-flow patterns in New Brunswick have been attributed to both the Laurentide Ice and to a system of local ice caps (Chalmers, 1902; Gadd, 1973; Rampton et al., 1984).

Chalmers (1902) noted the absence of erratics and flow indicators related to Laurentide ice in southern New Brunswick. To account for this, and multiple flow directions he had documented, Chalmers (ibid.) attributed the latest, and thus most pronounced, glacial activity to the Appalachian System of glaciers.

The Appalachian System consisted of a series of local ice-caps with radial flow patterns. In the study area, striae trending largely north-south were attributed to this system of glaciers (Chalmers, ibid.). Different orientations of striae were related to the same glacier at various stages of its advance or withdrawal (Chalmers, ibid.).

In southwestern New Brunswick, Gadd (1973) inferred two main ice flow directions, to the south and southeast. He attributed these to two separate patterns of coexisting ice lobes. Gadd (ibid.) divided ice retreat into seven phases, based on the distribution and orientation of moraines and esker systems. The phases indicated a retreat pattern to the northwest. No evidence for earlier phases than the seventh,

the Canterbury - Marysville Phase, is documented in the study area (Gadd, ibid.).

During the seventh phase, the ice margin lay south of Canterbury and extended across to Lower Prince William (See Figure 3.1 for place names). Prior to this phase, ice traversed the Saint John River, along with its associated esker systems. During deglaciation, drainage was confined to southward flowing glacial channels. Gadd (ibid.) suggested that the eskers in the area were topographically controlled by an ice lobe occupying the lower reaches of the Saint John River valley.

Rampton et al. (1984) divided the Late Wisconsinan in New Brunswick into six phases of ice-flow based on regional patterns. These phases were named: Chignecto; Bantalor; Millville/Dungarvon; Plaster Rock; Chaleur; and Madawaska.

During the Chignecto Phase (15 to 18 ka) eastern New Brunswick was influenced by the Escuminac Ice Centre, located northeast of the province near the northwest end of Prince Edward Island. In western New Brunswick, the North Maine Ice Divide may have produced ice flow patterns trending to the southeast, blocking Laurentide ice from the area of Quebec (Rampton et al, ibid.). The position of the Divide may have shifted due to influences of Laurentide and Appalachian ice (Pronk et al., 1989).

The Bantalor Phase was marked by the influence of the Gaspereau Ice Centre over most of central eastern New

Brunswick, limiting activity by the Escuminac Ice Cap to the far eastern portions of New Brunswick (Rampton et al, ibid.). Southeastern flow directions in the west (Tay and Woodstock flow patterns): appear to have originated from the North Maine-Notre Dame Ice Divide in the northwest (Rampton et al., 1984). During this phase the New Brunswick Lowlands, believed to have been deglaciated by 13 ka, were submerged (Rampton et al., ibid.).

During the Millville/Dungarvon Phase, ice flow in western New Brunswick was confined to terrain adjacent to the Saint John River Valley. The maximum extent of the North Maine Ice Divide during this period was to the southeast of the Canterbury area. This phase was characterized by large esker and valley train glaciofluvial systems. Lee (1962) suggested that most of the ice-contact and glaciofluvial sediments in the Canterbury area were deposited along the margin of the retreating ice, within the confines of the incised Saint John River Valley. Ice flow directions were to the south-southeast. Marine submersion supposedly reached Fredericton by 12.7 ka (Rampton et al., ibid.).

The last three phases, Plaster Rock, Chaleur and Madawaska, were restricted to the northern portions of New Brunswick, and had little influence in the study area. These phases marked the end of Late Wisconsinan glaciation in New Brunswick (Rampton et al., ibid.).

Climatic warming appears to have started around 12.6 ka as ice continued to retreat in New Brunswick (Rampton et al., ibid.). Rapid deglaciation in coastal areas may have resulted from ablation of the ice caps by calving, caused by the higher sea level, or from lack of precipitation due to cooler temperatures.

The Holocene was marked by crustal uplift in central New Brunswick and submergence in coastal areas. As emergence continued, self-entrenchment of the Saint John River is believed to have produced the multiple terraces found along the Saint John River Valley (Rampton and Paradis, 1981).

CHAPTER 2

FIELD AND LABORATORY METHODS

The Canterbury area was mapped by the author for the New Brunswick Department of Natural Resources and Energy (N.B.D.N.R.E.), Fredericton, during the summers of 1990 and 1991. Sample sites were based on a 2 km^2 grid pattern over the Canterbury map sheet (N.T.S. 21 G/14). This grid was chosen by N.B.D.N.R.E. to obtain uniform sampling across the area (Figure 2.1).

A total of 273 samples, including pebbles, were collected from grid points across the study area (Figure 2.1). Samples were collected from natural exposures or excavated sample pits at all grid points. Sample pits were excavated by hand and sampled at an average depth of 0.75 metres, using stainless steel implements. Detailed logs of the pits and the surrounding area were recorded. All samples were collected from the C-horizon.

Surficial mapping was performed along the major access routes via truck and canoe to determine unit contacts. Exposed bedrock was studied for glacial-erosional indicators and to verify existing bedrock maps of the area. Sand and gravel exposures were investigated to determine their relationship to other deposits in the area.

Samples were analyzed for lithology (Appendix II), grain size (Appendix III) and geochemistry (Appendix IV).

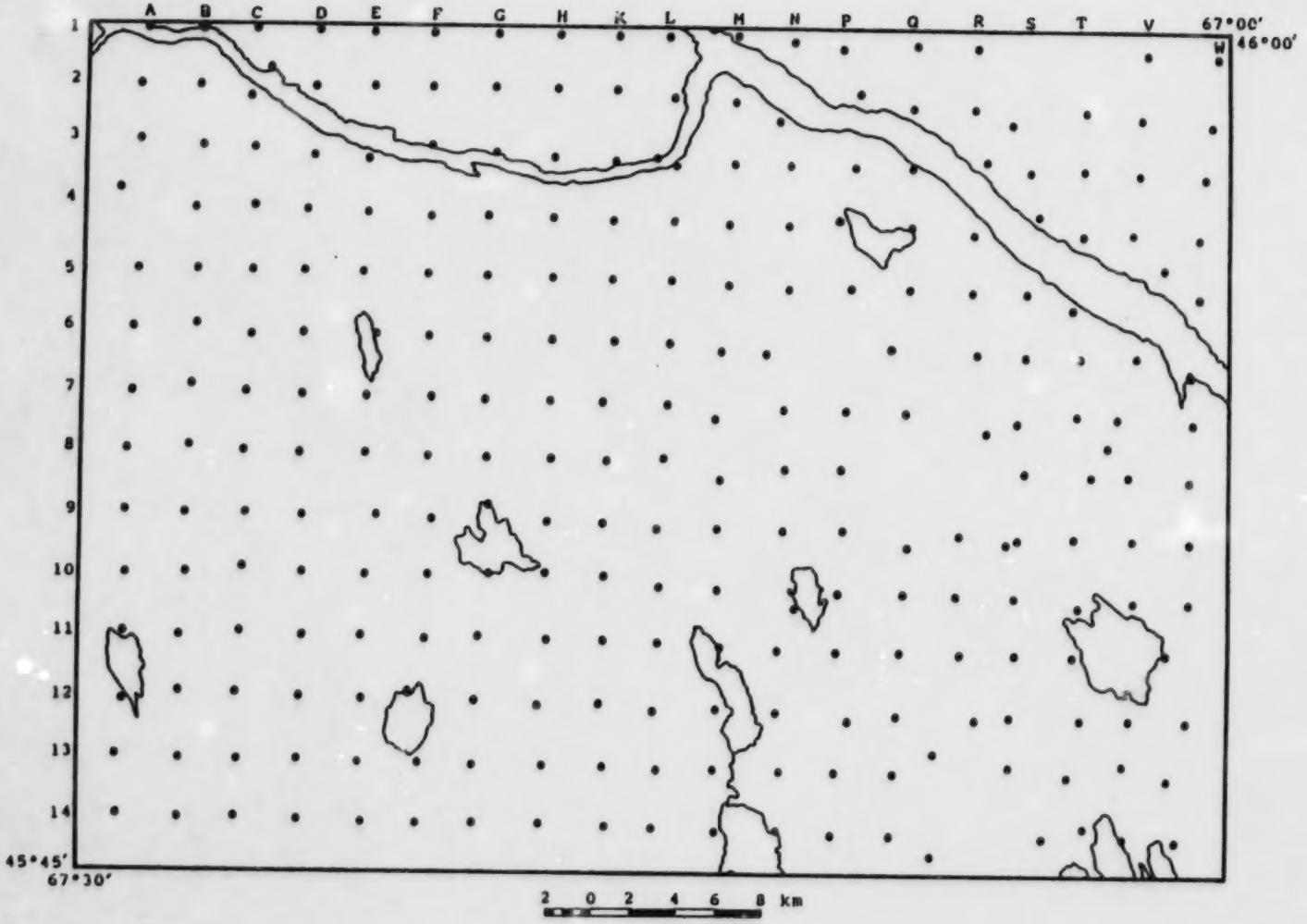
Granulometric analyses were conducted on 270 samples according to modified ASTM (1964) procedures (See Appendix III for details on the modification). Sand/silt/clay ratios were calculated according to ASTM (1964); graphic means, inclusive graphic standard deviation, inclusive graphic skewness, and graphic kurtosis (Appendix III) were calculated by hand according to Folk (1974).

Pebble clasts and sediment matrices were investigated to determine lithology and provenance. Individual lithologic groups were plotted by hand and SURFER® to delineate areal dispersal patterns and their maximum extent of elongation.

Granulometric and lithological data were analyzed for possible correlations using non-parametric, multivariate statistics. The analysis was performed using Statistical Package for Social Sciences® (S.P.S.S.). No significant correlations were found using this method, due to the multi-lithological nature of the bedrock. It has therefore, not been included in this study.

The clay-silt fractions were analyzed geochemically, for base metals, trace and Rare Earth elements. Atomic Absorption Spectrophotometry (A.A.S.), performed by the N.B.D.N.R.E. Geochemical Lab, was used to determine base metal concentrations. Trace and Rare Earth element abundances were obtained by Induced Neutron Activation Analysis (I.N.A.A.), performed by Activation Labs Ltd.

Figure 2.1 Example of sample grid used in the study area. Sites are denoted by black dots. Exact sample site locations are given in Appendix I.


A B C D E F G H K L M N P Q R S T V
1 2 3 4 5 6 7 8 9 10 11 12 13 14
67°00' W
46°00'
45°45'
67°30'
2 0 2 4 6 8 km

The accuracy and precision of the geochemical data were evaluated by comparison with analyzed standards and replicate samples. Most elements analyzed by I.N.A.A. were within the acceptable range of values for N.B.D.N.R.E. Standards (See Appendix IV, Table IV.1). Multiple runs on the standards using I.N.A.A. produced consistent results (See Appendix IV, Table IV.2).

No standards were analyzed using A.A.S. and therefore accuracy of the results is unknown. Several sample runs were duplicated to examine consistency of the results (See Appendix IV, Table IV.3). These runs produced identical or close values for the elements.

CHAPTER 3

LOCATION AND BEDROCK GEOLOGY

3.1 Location and Access

The study area is located in southwestern New Brunswick, between Fredericton and Woodstock (Figure 1.1). It is represented by the Canterbury topographic map sheet (N.T.S. 21 G/14, scale 1:50 000). Canterbury and Nackawic are the largest communities in the area (Figure 3.1).

This area can be accessed by road and canoe. The main access roads in the area are the Trans-Canada Highway (#2), and secondary highways (105, 122, 636, 635, and 630). Private logging roads provide the best access to the interior of the study area.

Due to high water tables and dense vegetation, winter roads and game trails provide access by foot only. A canoe was used to collect samples and survey the shorelines of the larger lakes and parts of the Saint John River near Pokiok.

3.2 Physiography and Drainage

The study area is located in the St. Croix Highlands Physiographic Zone (Rampton et al., 1984), a subdivision of Bostock's (1970) Appalachian Region. The main physiographic feature in the area is the Saint John River, which crosses the northern portion of the map sheet (Figures 3.1 and 3.2).

Figure 3.1 Location map for study area.

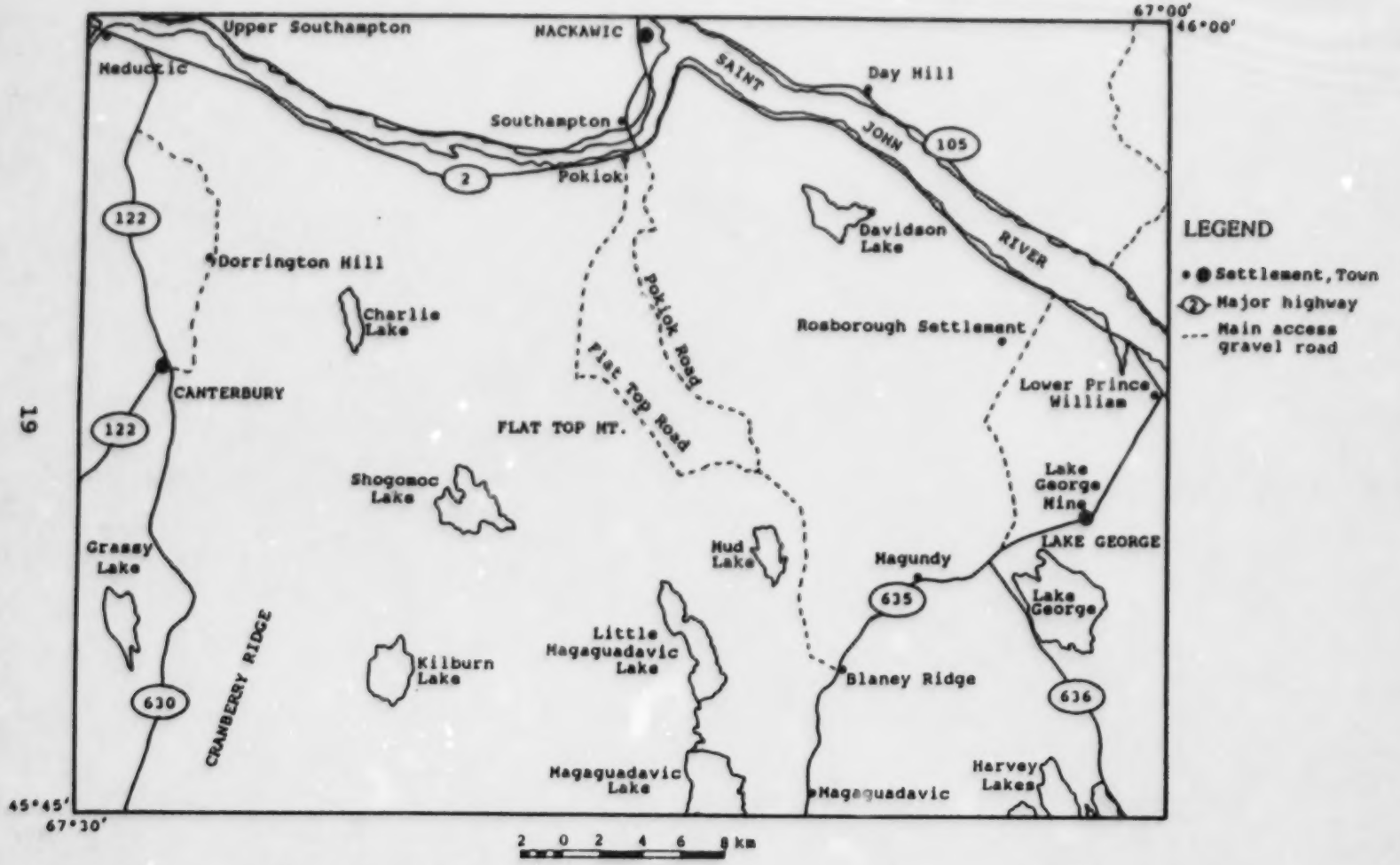
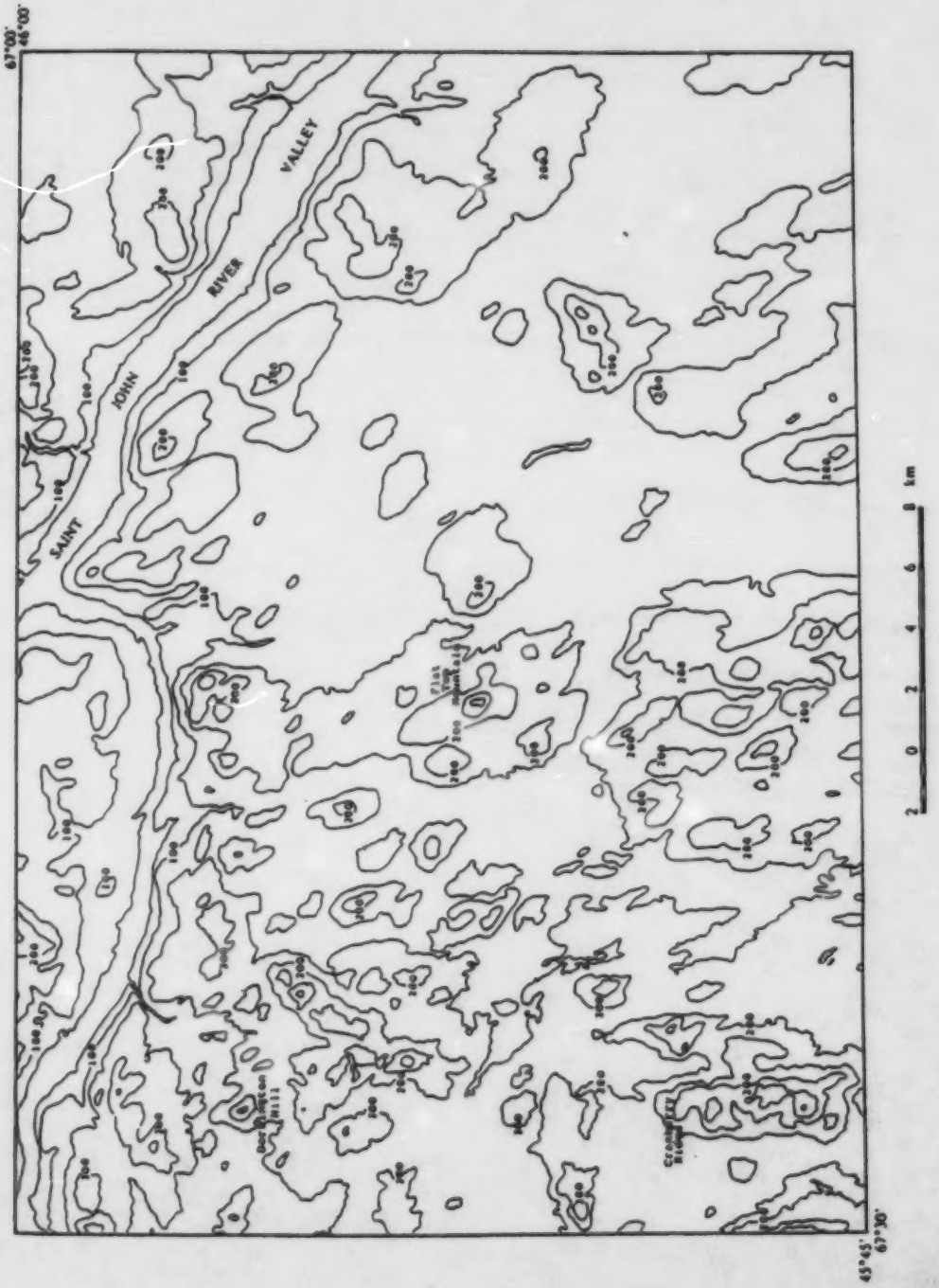

67°00'
46°00'
Upper Southampton
NACKAWIC
Meductic
SAINT
JOHN
RIVER
Day Hill
Southampton
105
2
Pokiok
122
Davidson Lake
Dorrington Hill
Pokiok Road
Charlie Lake
Rosborough Settlement
CANTERBURY
Lower Prince William
122
FLAT TOP MT.
Flat Top Road
Shogomoc Lake
Lake George Mine
LAKE GEORGE
Grassy Lake
Mud Lake
Magundy
635
Lake George
CRANBERRY RIDGE
Little Magaguadavic Lake
Kilburn Lake
Blaney Ridge
630
636
Magaguadavic Lake
Harvey Lakes
Magaguadavic
45°45'
67°30'
2 0 2 4 6 8 km
LEGEND
Settlement, Town
Major highway
Main access gravel road

Figure 3.2 Topography of the study area. Contours are in 50 metre intervals.


67°00'
46°00'
SAINT JOHN RIVER VALLEY
45°45'
67°30'
2 0 2 4 6 8 km

Northeast of the river, low hills slope gently to the south, forming broad terraces. Terraces also occur along the south bank of the river towards Lower Prince William (Figure 3.1). West of Pokiok, dissected glaciofluvial sediments and exposed bedrock flank the river.

The completion of the Mactaquac Dam in 1968 flooded most of the Saint John River's tributaries. The present reservoir level lies 41 metres above the previous river level (Seaman and Broster, 1990), obscuring earlier documented stratigraphic sections.

Drainage of the study area is primarily by the Saint John River and its tributaries (Figure 3.3). The drainage pattern varies from rectangular in the area of granite bedrock, to modified dendritic in the area underlain by deformed metasedimentary and volcanic rocks. The western portion of the study area is well drained except for the narrower valleys. Some lakes in this area occupy elongated basins trending northwest-southeast. In the southeast portion of the study area, the Harvey and Magaguadavic Lakes are drained by the Magaguadavic River. Drainage in this area is imperfect to poor, resulting in extensive swamps and high water tables.

Large streamlined hills of granite and deformed metasedimentary rocks, typifying the western and southwestern portion of the study area (Figure 3.2), form the Pokiok Hills (Rampton et al., 1984). These hills are elongated in a northwest -

southeast direction. Elevations generally exceed 220 metres, up to a maximum of 406 metres (Cranberry Ridge). Local relief averages 100 metres. The hills are cut by narrow stream channels occupying broad, U-shaped valleys (Figure 3.2).

The Magaguadavic Highlands, a subdivision of the St. Croix Highlands (Rampton et al., 1984), is represented in the east by flat terrain underlain by Silurian sedimentary rocks. Elevations range from 210 to 241 metres, with small local relief. Swamps occupy broad depressions.

3.3 Bedrock Geology

Bedrock exposure in the study area is rare, and occurs mainly along logging roads and at tops of hills. Bedrock weathering penetrates up to one metre, although exceptions exist. Deeply weathered granite regoliths extending to depths >5 metres occur. At least six such areas have been found and are currently used as sources of aggregate by logging companies.

The study area contains portions of three main tectonostratigraphic zones (Fyffe et al., 1981; Lutes, 1987; Ruitenberg et al., 1977); the Central Platform; the Magaguadavic - St. Croix Zone; and, the Miramichi Anticlinorium (Figure 3.4). Each zone is subdivided into groups and formations (Figure 3.5) based on lithology, structure and age (Lutes, 1979, 1987; Venugopal, 1979). The

Figure 3.3 Drainage pattern of the study area.

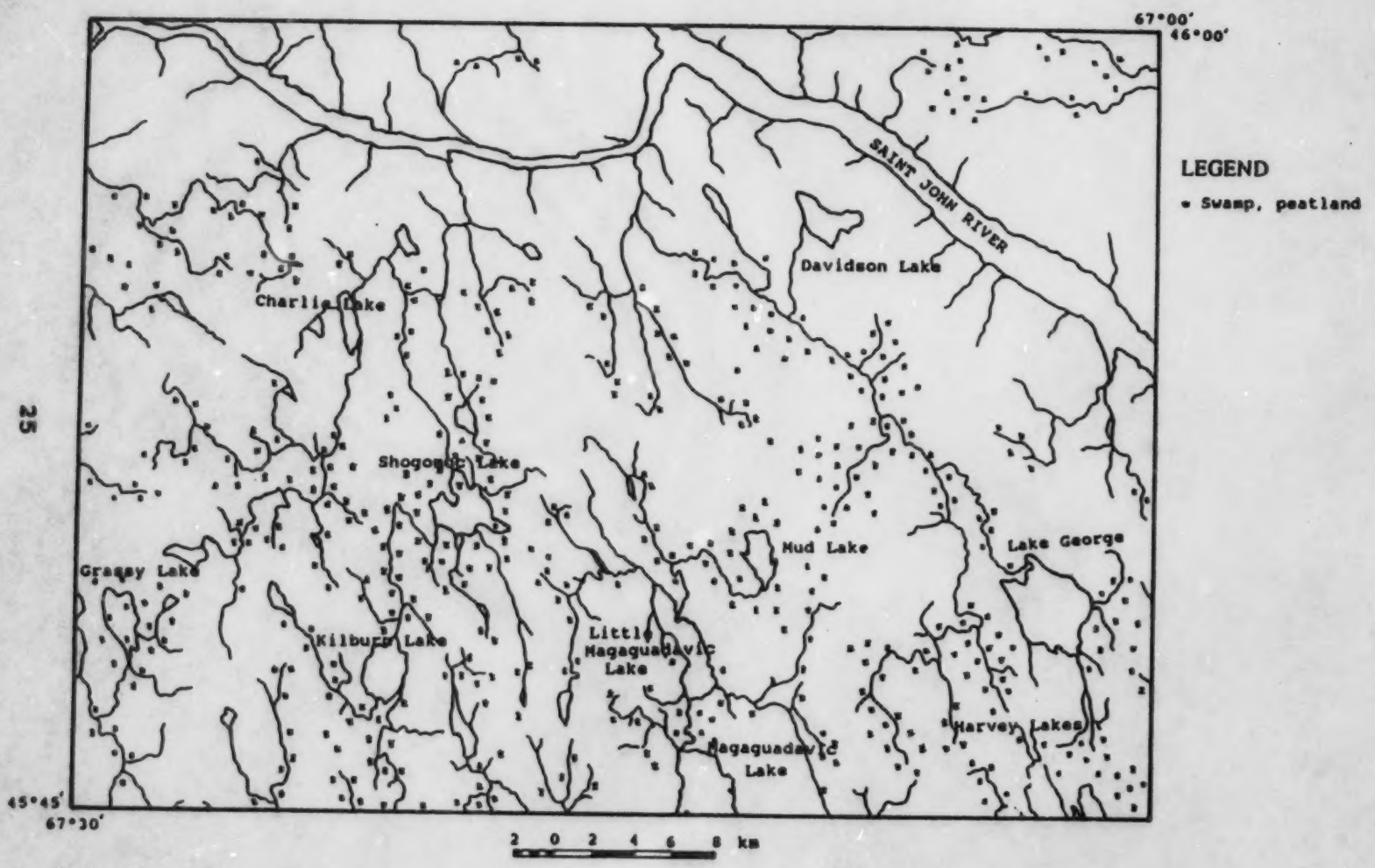

67°00'
46°00'
SAINT JOHN RIVER
Davidson Lake
Charlie Lake
Shogomoc Lake
Mud Lake
Lake George
Grassy Lake
Kilburn Lake
Little Nagaguadavic Lake
Nagaguadavic Lake
Harvey Lakes
45°45'
67°30'
2 0 2 4 6 8 km
LEGEND
• Swamp, peatland

Figure 3.4 Tectonostratigraphic zones of New Brunswick.
(After Rampton *et al.*, 1984).

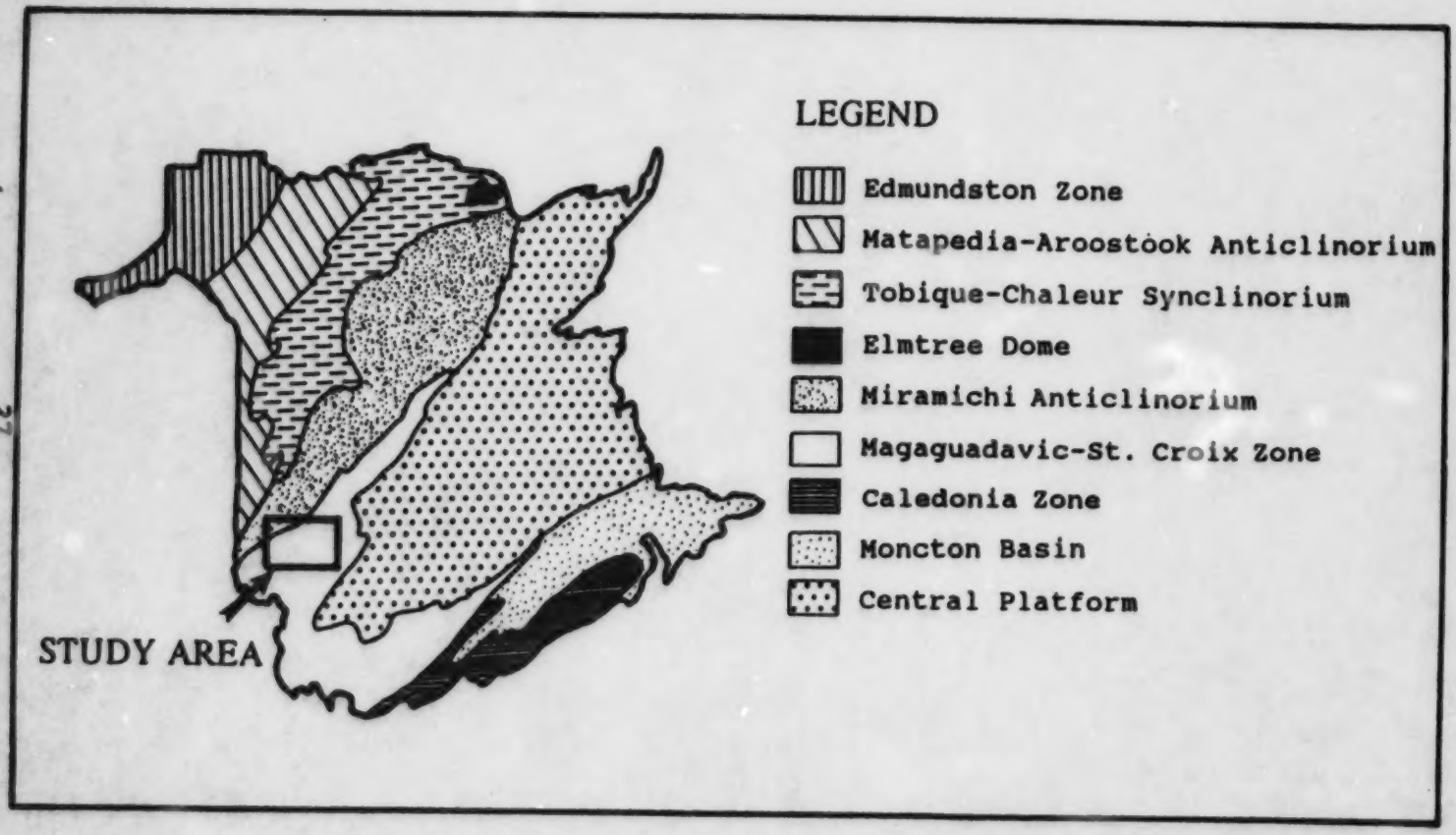
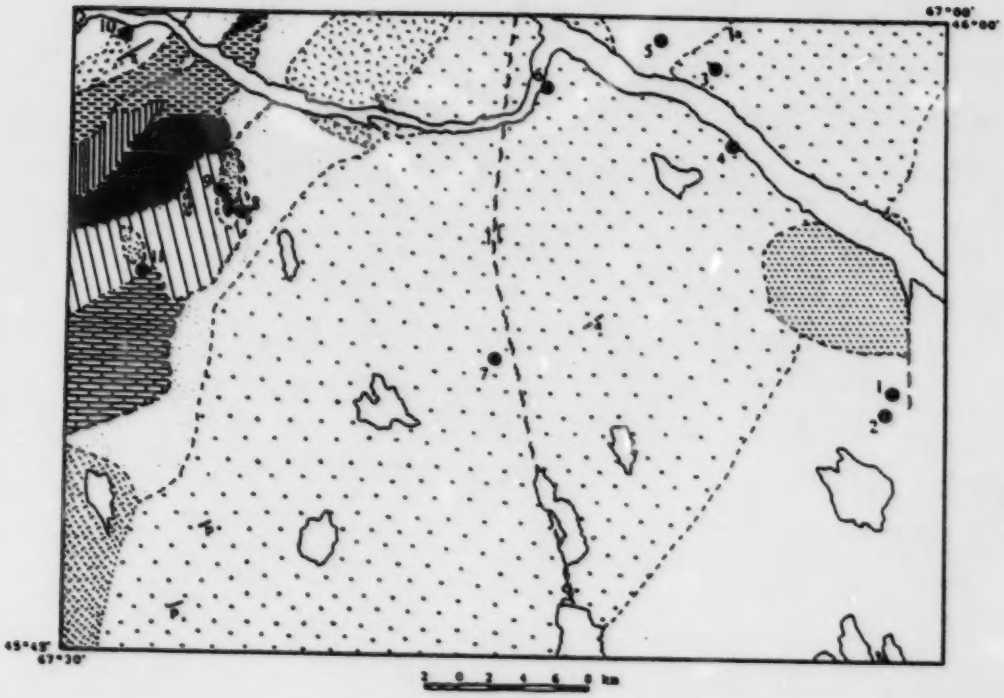

LEGEND
Edmundston Zone
Matapedia-Aroostook Anticlinorium
Tobique-Chaleur Synclinorium
Elmtree Dome
Miramichi Anticlinorium
Magaguadavic-St. Croix Zone
Caledonia Zone
Moncton Basin
Central Platform
STUDY AREA

Figure 3.5 Bedrock geology of the study area.
(Modified after Anderson and Poole, 1959;
Lutes, 1979, 1987: Venugopal, 1979;
Fyffe et al., 1981).



LEGEND

TRIASSIC

Ŧ Diabase dyke

CARBONIFEROUS

Sandstone, conglomerate, shale; minor ashflow tuff

DEVONIAN

Pokiok Batholith
- Hawkshaw Granite
- Skiff Lake Granite
- Hartfield Tonalite

Diabase, gabbro

SILURIAN-DEVONIAN

Dow Porphyry: feldspar quartz porphyry

Martin Formation: grey, calcareous sandstone and siltstone; minor white to grey limestone, mafic and felsic volcanics

Darrington Hill Formation: green mafic tuff; minor grey sandstone and grey felsic volcanics

Canterbury Limestone: grey to brown, thinly bedded limestone with minor interbedded calcareous sandstones and siltstones; minor conglomerate

Scott Sliding Slate: grey slate, grey sandstone (locally calcareous); minor grey limestone; lenses of grey conglomerate; green mafic volcanics

Magaguadavic - St. Croix Sedimentary Rocks: grey to brown greywacke, slates and conglomerates

ORDOVICIAN

Pocomoonshine Volcanics: grey to green felsic volcanics intercalated with thinly bedded red to green manganiferous siltstone and chert; green to grey, thinly bedded argillaceous siltstone and slate; minor green mafic volcanics

CAMBRIAN-ORDOVICIAN

Green metaquartzite, with thin interbeds of green slate, sandstone and siltstone

Dykes: a - aplite; t - tonalite; p - pegmatite

Fault (approximate, assumed)

Bedrock contact (approximate, assumed)

Mineral occurrence

1 Scheelite, molybdenite
2 Scheelite, stibnite, uraninite
3 Molybdenite
4 Wolframite, molybdenite
5 Chalcopyrite, scheelite
6 Fluorite
7 Molybdenite, chalcopyrite, galena, sphalerite
8 Pyrite, sphalerite
9 Chalcopyrite, sphalerite
10 Chalcopyrite, galena, sphalerite
11 Chalcopyrite, pyrrhotite, pyrite

Pokiok Batholith separates the Miramichi Anticlinorium and the Maguaguadavic - St. Croix Zone (Lutes, 1987).

Carboniferous sedimentary rocks of the Central Platform (Figure 3.5) occur as a small outlier in the Prince William area. This unit is composed of flat-lying continental sandstones, conglomerates and siltstones, with minor shales and ash-flow tuffs (Lutes, 1987). The Carboniferous rocks are iron-stained and fossiliferous. Most of the rock types are brown in colour, with the exception of local purple shales.

In the study area, the Magaguadavic - St. Croix Zone consists of deformed Silurian marine sedimentary rocks (Figure 3.5). Metamorphism is low-grade (Lutes, 1979). This sequence covers 25 % of the area, lying predominantly to the southeast. Lithologies include greywacke, slate, siltstone, sandstone, conglomerate and some limestone.

The Miramichi Anticlinorium (Figure 3.5) is represented in the study area by a sequence of Cambrian to Ordovician sedimentary rocks and volcanics. These are deformed, metamorphosed and intruded by plutonic rocks. This sequence is unconformably overlain by Silurian to Devonian sedimentary rocks and volcanics (Lutes, ibid.). Contacts are often faulted. Seven main formations and groups comprise this zone. Lithologic units within these groups are repetitive over large areas and are of use only for regional dispersal analyses. Devonian diabase and minor mafic volcanics occur in large

blocks north of Canterbury. A large diabase dyke, Triassic in age, occurs east of Meductic (Lutes, ibid.).

The Devonian Pokiok Batholith (Figure 3.5) extends northeast - southwest across the central portion of the area. This batholith is cut by the north-south trending Magaguadavic Fault. The batholith is subdivided into three units based on petrography: the Hawkshaw Granite; the Skiff Lake Granite; and the Hartfield Tonalite (Lutes, 1987).

The Hawkshaw Granite (Figure 3.5), largest of the above units, ranges from granodiorite to granite in composition. It is grey to pink in colour; and phaneritic to porphyritic in texture. Xenoliths of metasedimentary and mafic rocks are common (Lutes, ibid.). Numerous small dykes (pegmatites, tonalites and aplites) cut through the area. Aplite dykes are distinctive in lithology and restricted in size and therefore can be used for local dispersal analyses.

The second and third unit of the Pokiok Batholith, the Skiff Lake Granite and the Hartfield Tonalite (Figure 3.5), occupy smaller areas of the study area. The Skiff Lake Granite is similar in appearance to the Hawkshaw Granite. The Hartfield Tonalite is grey and coarse-grained, ranging in composition from hornblende-biotite tonalite to quartz-diorite (Lutes, ibid.).

3.3.1 Mineralization

Lutes (1987) noted several mineral occurrences in the study area (Figure 3.5). The Hawkshaw Granite is known to contain mineralization (fluorite, molybdenite, wolframite, chalco-pyrite, galena and sphalerite). Mineralization in the Silurian turbidites occurs in the Lake George Mine area. Minerals found include scheelite, molybdenite, stibnite and uraninite. Chalcopyrite and scheelite have also been found west of Day Hill (Lutes, ibid.).

Economic potential in the deformed metasediments and volcanics in the west is poor. The only units currently known to contain mineralization are the Pocomoonshine Volcanics (Cu-Pb-Zn minerals) and the Hartin Formation (pyrrhotite, pyrite, ilmenite) (Figure 3.5).

CHAPTER 4

SURFICIAL GEOLOGICAL MAPPING

Glaciation, weathering, isostatic rebound, paludification, alluviation, stream erosion, and industrial development have contributed to the current surficial geology of the study area.

The surficial geology of the area was divided into several units (Map 92-68) during field mapping by the author. These units were defined based on similar genetic origin, composition and morphology. The symbols and genetic classifications used are based on the system currently in use by the Geological Survey of Canada (e.g. Aylsworth and Shilts, 1987; Hughes, 1989).

Deposits are placed in a genetic category and given morphological modifiers. The genetic categories are: O (organic); C (colluvial); A (alluvial); G (Glaciofluvial); M (morainal); and, R (bedrock, grus). The morainal deposits were given further modifiers indicating specific till units: M_P (Pokiok Till); M_{DH} (Dorrington Hill Till); M_{HB} (Hammond Brook Till); and, M_{LG} (Lake George Till).

Morphological modifiers are: b (blanket, thickness > 2 metres); d (drumlinoid); h (hummocky); m (rolling); p (plain); r (ridged); t (terrace); v (veneer, thickness < 2 metres); x (complex, combination of modifiers); and, l (delta).

4.1 Morainal Deposits

Most of the area is overlain by basal till (sensu stricto, Dreimanis 1976). The loose material overlying the basal till is due to soil-forming processes, ablation and reworking by glacial meltwater.

Four basal till units were recognized by the author in the study area, and informally named herein as: the Pokiok; the Dorrington Hill; the Hammond Brook; and, the Lake George (Map 92-68). Each unit can be delineated by specific characteristics, including matrix and clast lithology, texture, colour (eg. mottling), and underlying bedrock type. The lack of multiple till units that overlie each other in stratigraphic exposures suggests that these divisions likely represent different facies of a single till, rather than separate tills.

4.1.1 Pokiok Till (M_p)

Basal till overlying the granites tends to be very compact, gritty and usually silty-sandy to sandy (Map 92-68). The colour is greyish brown to grey, and may have pink tinges. The matrix and granule size fractions are high in granite content. Foreign clast content is variable near lithologic contacts and glaciofluvial sediments.

Till thickness is variable and difficult to determine. Most topographic highs are thinly veneered by till. Logging roads have exposed sections up to 2 metres high of granitic

till grading into grus. In the lower regions and in depressions, thickness could well exceed several metres, as documented by Lee (1962) along the Saint John River.

Boulder lags are associated with the Pokiok Till. The boulders are usually granitic, although occasionally composed of schist or metasediment. Boulders range in size from a few 10's centimetres to several metres. Boulder concentrations exceeding 50% of surface cover is common. Higher concentrations of boulders (up to 90% of surface cover) occur in the Shogomoc and Kilburn Lake areas (Map 92-68).

During field examination, a gradational change from the Pokiok Till into the Lake George Till was identified southwest of the granite-turbidite contact (Map 92-68). The till in this area is similar to the Pokiok Till, but contains a higher proportion of silt in the matrix and is grey-brown in colour.

4.1.2 Dorrington Hill Till (M_{DH})

Till, overlying the metasedimentary rocks in the northwestern portion of the study area, is silty with variable sand and clay content. Colour ranges from greenish grey to various browns depending on the underlying lithology. Rare surface boulders consist of local metasedimentary rocks.

Till thickness is variable. At higher elevations, the till forms a veneer (<1 metre) overlying bedrock, giving the appearance of gently undulating uplands (Map 92-68). Moving towards the south, tha till becomes somewhat sandier and

thicker. Surface boulders become rare and the till colour becomes more greyish. The matrix of the till suggests a local origin (See Appendix II for visual determination of origin), containing no component of the granite units to the east.

A source for the ablation till over the northwestern area is difficult to determine because of the multi-lithologic nature of the underlying bedrock. The Dorrington Hill Till appears to curve around Dorrington Hill and extend in a southeasterly direction over the Hawkshaw Granite (Map 92-68). The matrix of the material in this till increases in granitic content to the southeast. This till may represent ablation material, however the unit is quite compact and commonly overlies bedrock.

4.1.3 Hammond Brook Till (M_{HB})

Till over the Carboniferous sedimentary unit, and slightly southeast of it, are sandy to silty, and brownish in colour, with the occasional purplish tinge. Clast lithology is mixed, containing granite and various metasedimentary rocks. Thickness is variable ranging from a thin veneer on the highs to thicker sequences in the southeast (Map 92-68).

4.1.4 Lake George Till (M_{LG})

South of Lake George, the till is drastically different than seen elsewhere in the study area (Map 92-68). The matrix is generally silty, with variable sand and clay content. The

Lake George Till is mottled, ranging from brown-beige to green-grey in colour.

Till in this area occupies flat plains with little relief. The abundant swamps and the high water table suggest low permeability of the till and underlying units. The lack of bedrock outcrops suggests that the till is quite thick. Surface boulders are rare.

4.2 Glaciofluvial Deposits

Glaciofluvial, ice-contact and outwash deposits are abundant throughout the study area(Map 92-68). These deposits have long been used as local sources of borrow and aggregate.

Eskers in the study area are small, with the exception of a large ridge informally referred to herein as the Pokiok Esker. This esker extends for about 27 kilometres and is part of a larger system located south of the study area (Seaman, oral personal communication, 1991). Eskers are low in relief, rarely exceeding 10 metres in height. They are cobbly to bouldery in texture, with lithologies reflecting the underlying bedrock. The Pokiok Esker is the only esker found to contain highly mixed lithologies, suggesting that it was probably a major system collecting material from different areas of the ice mass during glaciation. Paleocurrent measurements of esker exposures indicate meltwater flow to the south and southeast. Most eskers are flanked by extensive

outwash plains composed predominantly of sand. The lateral extent of the sand plains is obscured by swamps.

Broad terraces, kames, and kame deltas flank the Saint John River (Map 92-68). The incision of the river appears to have formed the terraces currently exposed. The deposits form elongate bodies of sand and gravel that parallel the Saint John River. Poor exposure of the deposits along the river make it difficult to determine flow directions. Most of the features exceed 15 metres in height (currently exposed) and are being mined as aggregate.

A kame-delta was exposed at Nackawic until the end of summer 1991, by which point most of the main body of the deposit had been removed by excavation. The kame-delta indicated strong flow direction into the Saint John River. High angle normal faulting on the northeast side of the kame delta is attributed to a loss of support during deglaciation, similar to the examples given in Broster and Clague (1987).

The sediments currently exposed along the Saint John River have undergone some fluvial reworking and erosion due to previous higher water levels, but how much is uncertain. The result of winnowing of the fines in till can be seen in units west of Pokiok. In low-lying areas, undercutting has eroded the banks and deposited silts and clays at the mouths of tributary streams.

4.3 Organics

Peatlands and swamps comprise a significant proportion of surface landforms in the study area (Figure 3.3 and Map 92-68). Lateral extent depends on the amount of precipitation received annually. Most of the peatlands occur along river channels and surrounding swamps. The majority of the peatlands are cut by rivers and streams and their elevations rarely exceed more than a few metres above the water level.

A peat study (Keys and Henderson, 1983) describes the larger peatbogs in the study area, with brief mentions of smaller ones. Several additional small peatbogs were found by the author during mapping of the area. One of the peat bogs drilled by Keys and Henderson (1983) identified underlying till. All other boreholes ended in bedrock or more commonly ooze or marl.

4.4 Bedrock

Bedrock exposure in the area is rare. Thinly veneered bedrock is found over the granites and near the Dorrington Hill area. In these areas, the streamlined nature of the bedrock is readily apparent.

Extensive exposures of weathered granite, termed grus, were found near Charlie Lake (and surrounding vicinity), Nackawic, northeast of Day Hill, west of Southampton, and along Flat Top Ridge (Figure 3.1 and Map 92-68). Many of these deposits are currently used for borrow by logging companies.

These deposits resemble granite and appear initially as consolidated bedrock, but are very friable due to extensive weathering. Grus has been found at depths over 5 metres, suggesting considerable weathering prior to Late Wisconsinan glaciation.

Glacigenic rafting has been reported in the Charlie Lake vicinity (Broster and Seaman, 1991). Further evidence of glacigenic rafting was not found in the study area, possibly due to a lack of well preserved exposures.

4.5 Erosional Indicators

The lack of exposed bedrock, deep weathering and its poor condition for recording striae has limited the number of sites with well preserved erosional indicators that could be used to determine ice-flow patterns in the study area. Glacial erosional features, mapped by the author during the summers 1990 and 1991 (Figure 4.1), indicate south to southeast ice flow directions conformable to previous investigations in the area (Chalmers, 1885, 1886, 1902; Lee, 1962; Gadd, 1973; Rampton et al., 1984; Seaman, 1989, 1991; Seaman and Broster, 1990; Broster and Seaman, 1991).

Striae, rat tails, grooves, roches moutonnées, and chatter marks are the most common erosional features. Indicators on granites were dominantly grooves, roches moutonnées and chattermarks. Rat tails were common over the

Carboniferous and Silurian conglomerates. Striae, grooves and chattermarks were seen on finer-grained bedrock lithologies.

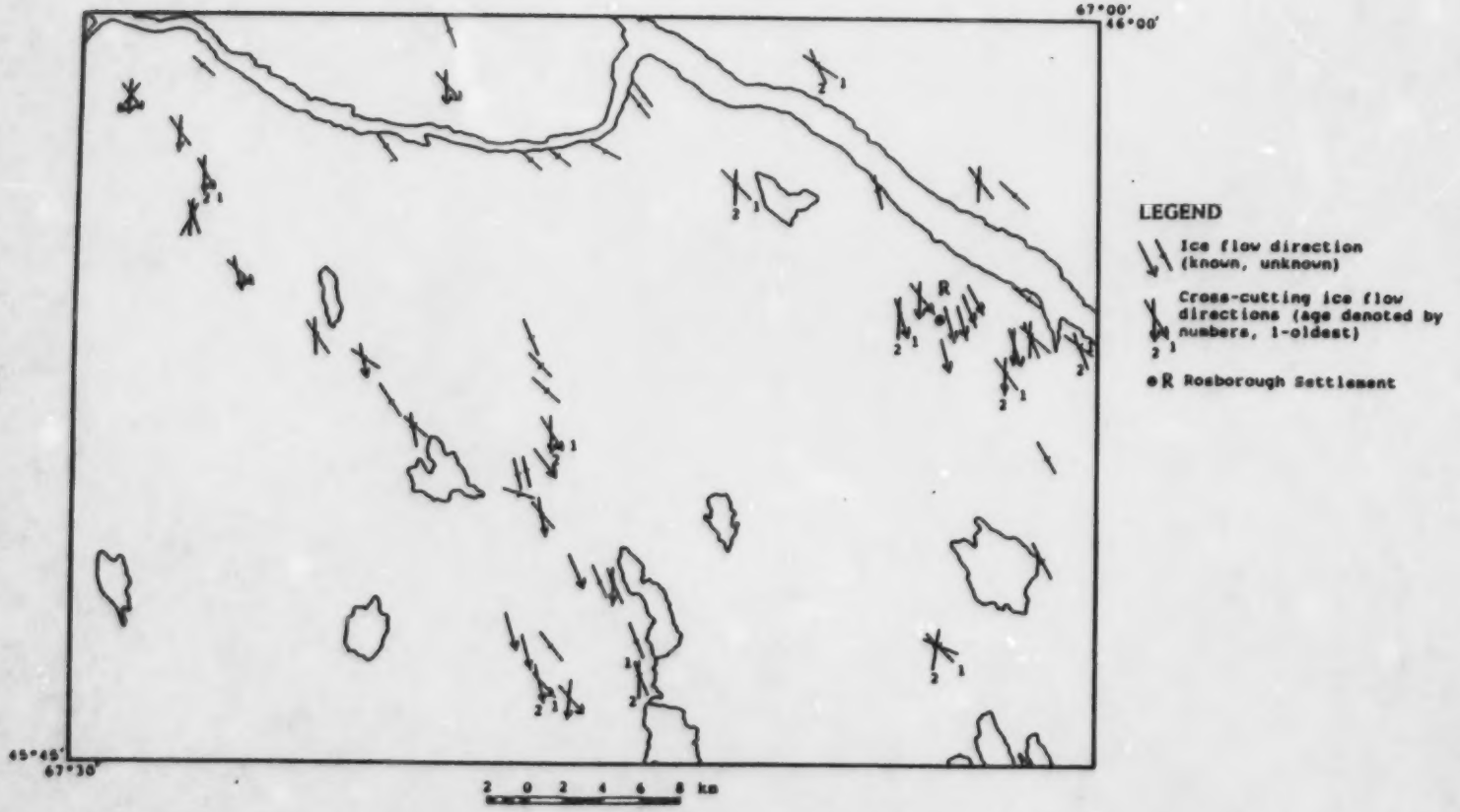
Glacial erosional features in the area indicate a strong, regional, south to southeastward flow direction (Figure 4.1). Striae, grooves and rat tails on sites along the Saint John River indicate ice flow paralleling the river valley.

Several locations indicate multiple ice-flow directions. In such cases, one direction dominates, while the others are much finer. Often the striae seem to splay out, cross-cutting themselves with no apparent dominant direction. These sites occur near physiographic obstructions (eg. before or after a hill, and in valleys), areas where changes in ice velocity or direction are the most likely.

Age relationships are determined by cross-cutting sets of striae or grooves, and truncated rat tails. Along the Saint John River, earliest movement parallels the river, curving towards to southeast in the eastern portion of the study area (Figure 4.1). Cross-cutting striae and rat tails on outcrops near Prince William and Rosborough Settlement are interpreted as an indication of a gradual change in direction of ice flow from southeast to south. Striae and rat tails indicating the southward ice flow are small and less pronounced than similar features indicating southeastward ice movement. This weaker ice flow direction may be the result of thinner ice.

Many of the hills in the study area, particularly in the west, are streamlined and almost drumlinoid in appearance.

Figure 4.1 Glacial erosional ice-flow indicators in the study area.


67°00'
46°00'
45°45'
67°30'
R
2 0 2 4 6 8 km
LEGEND
Ice flow direction (known, unknown)
Cross-cutting ice flow directions (age denoted by numbers, 1-oldest)
2 1
R Rosborough Settlement

These hills trend in the same south to southeasterly pattern as other erosional indicators (Figure 4.1). The presence of glacial deposits and erosional features in the area suggests that the hills were glacially modified. Whether that modification was a result of the glacial ice responsible for most of the deposits currently seen, or to previous events, is not known.

CHAPTER 5

RESULTS OF LITHOLOGICAL, GRANULOMETRIC AND GEOCHEMICAL ANALYSES

5.1 Pebble Lithology

Lithological studies were performed on samples collected from 247 sites. At least 50 to 100 clasts from each sample were analyzed for lithology (Appendix II). The results were plotted as percentages.

Plots of the normalized data for seven lithology groups were contoured to determine areal dispersal patterns. These include: granites (including tonalites); eastern sedimentary rocks (Magaguadavic-St. Croix zone); western sedimentary rocks (Miramichi zone, not including volcanics); volcanics; felsic dykes (aplite and porphyry); mafic intrusions (gabbro and diabase); and, purple slates.

Three lithologies were found to be diagnostic of ice-flow direction (as discussed below): granites; aplites; and, volcanics.

5.1.1 Western and Eastern Sedimentary Rocks

The highest concentrations of clasts from the western and eastern sedimentary rock groups are associated with till overlying the Miramichi and Magaguadavic - St. Croix zones. Clasts from the Miramichi zone occur over most of the area. Clasts from the Magaguadavic - St. Croix zone occur only in

the southeastern portion of the study area, but rarely in sediments overlying the granite. A dispersal train of western metasedimentary clasts extends over the granites; decreasing southeastward.

5.1.2 Volcanics

Volcanics occur in till overlying metasedimentary units and granites in the western portion of the study area. Volcanic clasts in the till decrease to a minor constituent, six kilometres southeast of the meta-sediment/granite contact.

Distinct, ribbon-shaped dispersal trains can be traced in the study area near Canterbury and Dorrington Hill (Figure 5.1). The dispersal trains are elongated approximately 8-10 kilometres towards the southeast. Volcanics occupy a significant volume of the bedrock in this area (Figure 3.5).

5.1.3 Granites

Till overlying the Pokiok Batholith is dominated by granite clasts (Figure 5.2). High granite clast concentrations are associated with the Pokiok Esker and its outwash plains.

Granite clasts are rare in sediments overlying the metasedimentary units in the northwest portion of the study area. They occur near eskers and flank the Saint John River. Granite clasts are rare in till overlying the eastern portion of the study area, although significant granite clast

concentrations are traceable up to eight kilometres southeast of the granite/Silurian sedimentary bedrock contact.

5.1.4 Felsic Dykes

The concentration of fine-grained aplite clasts is low, but distributed over a wider area. Nine dispersal trains of aplite clasts occur in till overlying the Pokiok Batholith and the sedimentary units in the east (Figure 5.3). The dispersal trains are irregular in shape, showing elongation to the south and southeast. Aplite clasts are traceable for 8-10 kilometres.

The largest dispersal train of aplite clasts is located west of Rosborough Settlement (Figure 5.3). This train extends approximately 20 kilometres to the south. The presence of three local areas high in aplite clast content suggests that the train may be a composite of three smaller ones. The lower portion of this train parallels the Pokiok Esker in the area where they contact. Aplite clasts are not found in the esker upstream of the area where contact has occurred.

Rhyolite porphyry clasts are easily identified, but they are not of sufficient frequency to be traced successfully in the study area.

5.1.5 Mafic Intrusives

Diabase and gabbro clasts occur mainly in till overlying the metasedimentary units in the northwest. Mafic intrusive

Figure 5.1 Dispersal pattern of volcanic clasts. Contour interval is 10 %. (Contoured by hand) Dashed line represents the granite/metasedimentary contact. Granite lies southeast of the contact.

C - Canterbury

D - Dorrington Hill

R - Rosborough Settlement

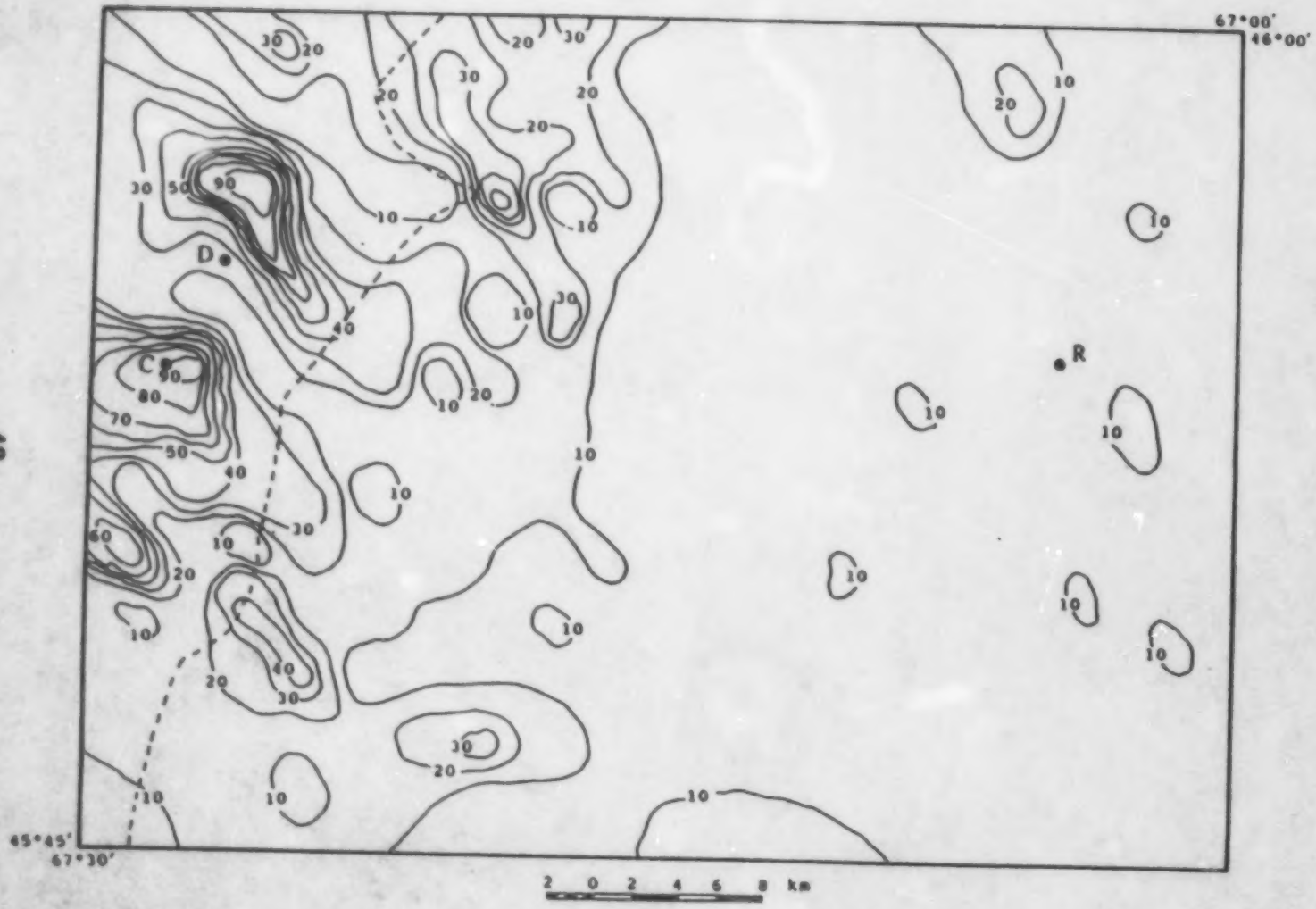

67°00'
46°00'
45°45'
67°30'
D
C
R
2 0 2 4 6 8 km

Figure 5.2 Dispersal pattern of granite clasts. Contour interval is 20 %. (Contoured by hand). The Pokiok Batholith occupies the central area between the dashed lines. Shaded area represents the Pokiok Esker and its outwash plains.

C - Canterbury

D - Dorrington Hill

R - Rosborough Settlement

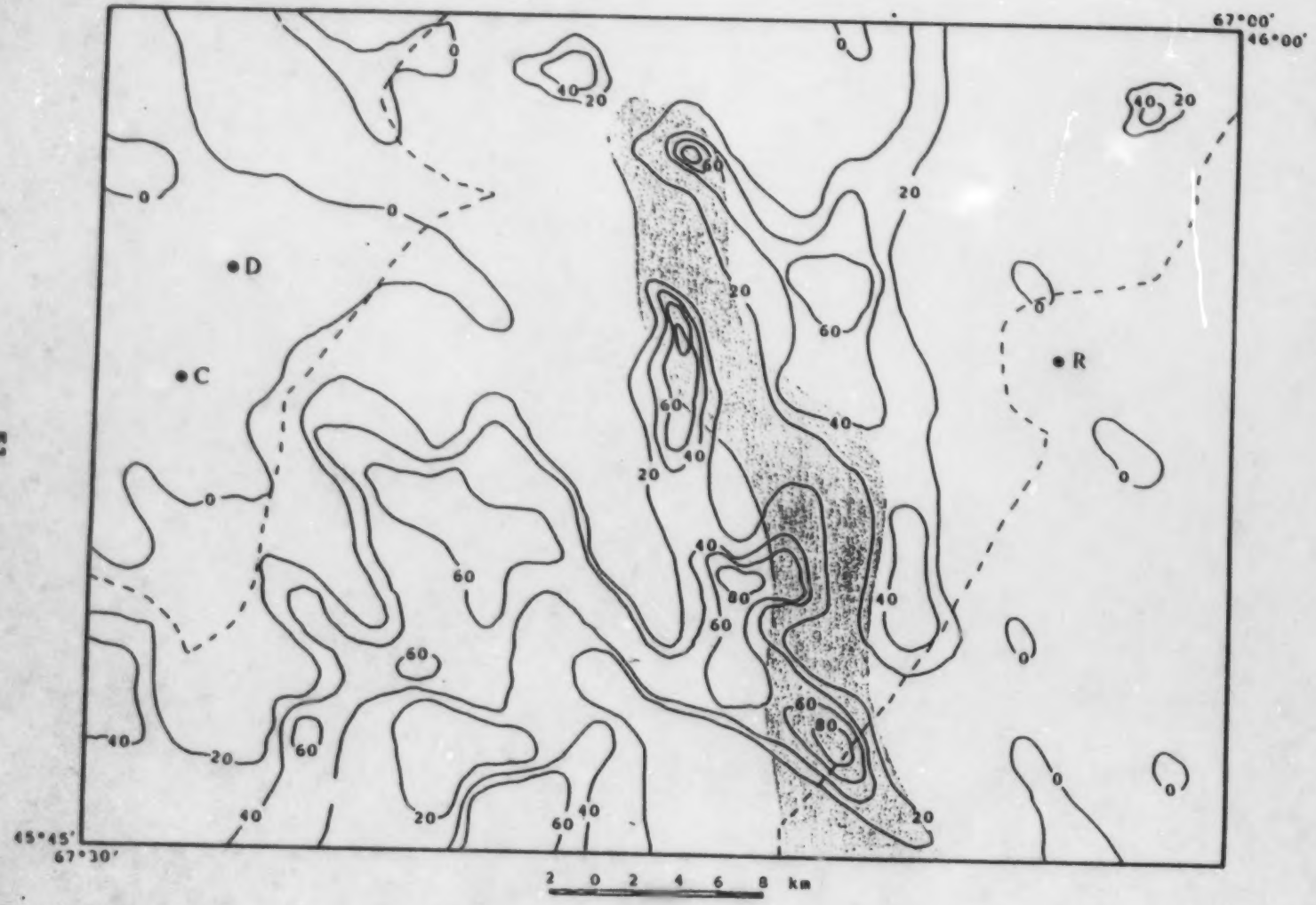
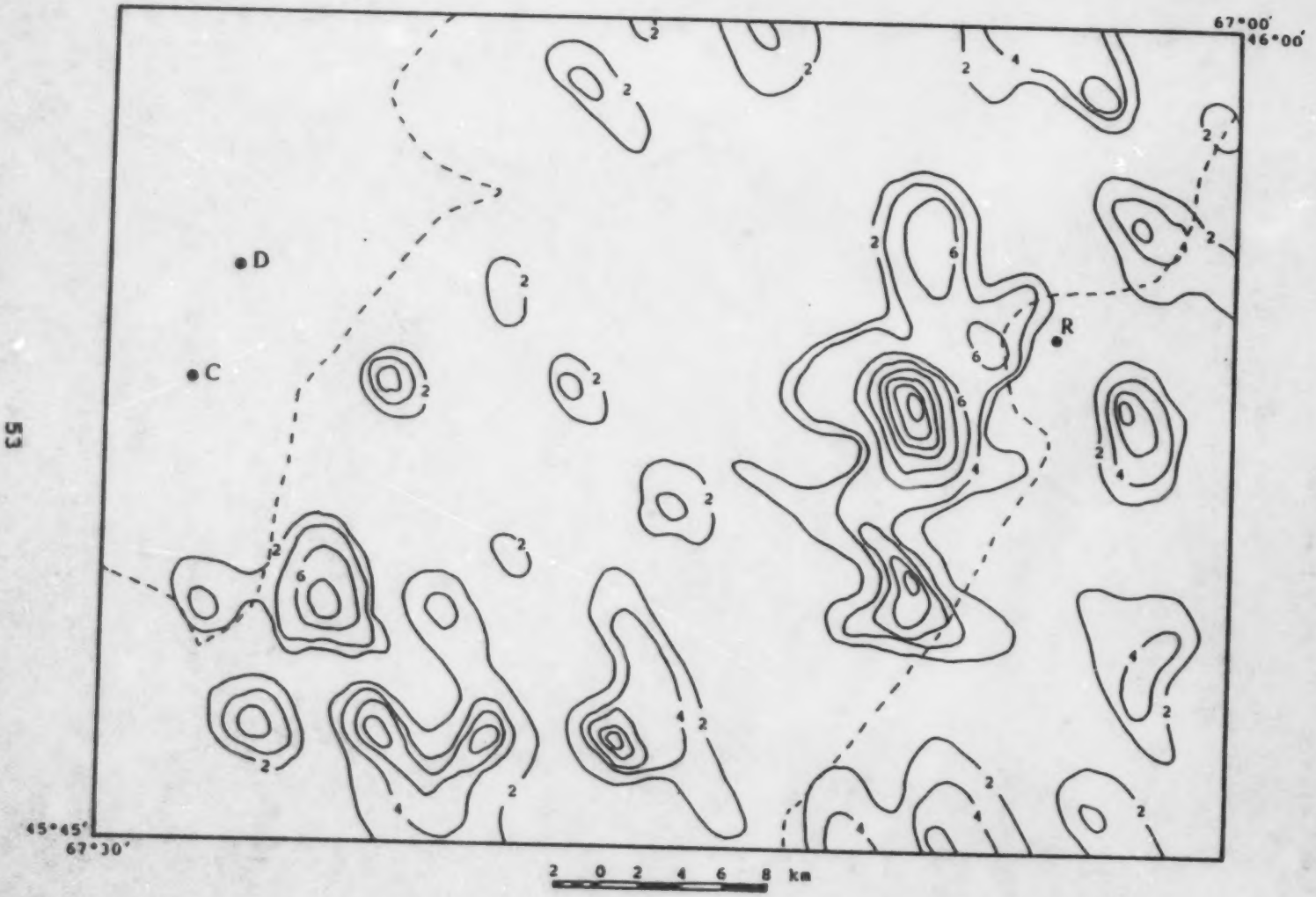

67°00'
46°00'
45°45'
67°30'
D
C
R
0
20
40
60
80
2 0 2 4 6 8 km

Figure 5.3 Dispersal pattern of aplite clasts.
Contour interval is .2 %. (Contoured by hand).
Pokiok Batholith occupies the central portion
between the dashed lines.
C - Canterbury
D - Dorrington Hill
R - Rosborough Settlement


67°00'
46°00'
D
C
R
45°45'
67°30'
2 0 2 4 6 8 km

clasts can be traced in till up to 8 kilometres southeast of the metasediment/granite bedrock contact (Figure 5.4).

Individual dispersal trains are poorly defined, small and localized. High concentrations of mafic intrusive clasts in till near Rosborough Settlement, form a dispersal train (Figure 5.4). This train, elongated towards the south, curves to the southeast near the Lake George Mine. No mafic intrusives have yet been documented by ground traverses and aeromagnetic studies (Anonymus, 1953) in the this area (Figure 3.5).

5.1.6 Purple Slates

The distinctive colour of these clasts (purple to maroon) make them easy to recognize in the study area. However, the occurrence of these clasts is rare. A few clasts are found southeast of the Central Platform slates, but are too low in concentration to properly define a dispersal train.

Abundant slate clasts are found in glaciofluvial deposits flanking the Pokiok Esker and the Saint John River, near Upper Southampton. Purplish slates may occur in sedimentary units north or northwest of the study area.

5.2 Matrix Lithology

Areal dispersal of matrix lithology for till and glaciofluvial deposits indicate strong correlations with underlying bedrock (Figure 5.5).

In the northwestern corner of the study area, sediment matrices are dominated by local metasedimentary lithologies,with no granitic component. Granitic content increases in the matrices towards the southeast. South of Canterbury, the transition from matrices dominant in metasedimentary lithologies to those dominant in granite is complete within six kilometres of the metasediment/granite contact (Figure 5.5). North of Canterbury, the transition occurs over a broader area. The large, southeasterly dispersal train, defined by metasediment clasts in the till, is reflected in the matrix.

Glaciofluvial sediments along the Saint John River and the Pokiok Esker contain high concentrations of metasedimentary lithologies in their matrix. Local metasediments comprise most of the matrix component of tills in the Lake George area. Sediments with matrices rich in granite occur south of the granite/turbidite contact. This area contains abundant granite clasts and erratics. Higher granitic components in the matrix of sediments west of Lake George are associated with two smaller eskers in the vicinity.

5.3 Granulometric Data

The homogeneity of till in the study area is reflected in the areal distribution of the granulometric data. Graphic statistics are related to the sand/silt/clay ratios, reflecting similar distribution patterns.

Figure 5.4 Dispersal pattern of mafic intrusive clasts. Contour interval is 10 %. (Contoured by hand) Metasediment/granite contact represented by the dashed line. Granite lies to the southeast of the contact.

C - Canterbury

D - Dorrington Hill

R - Rosborough Settlement

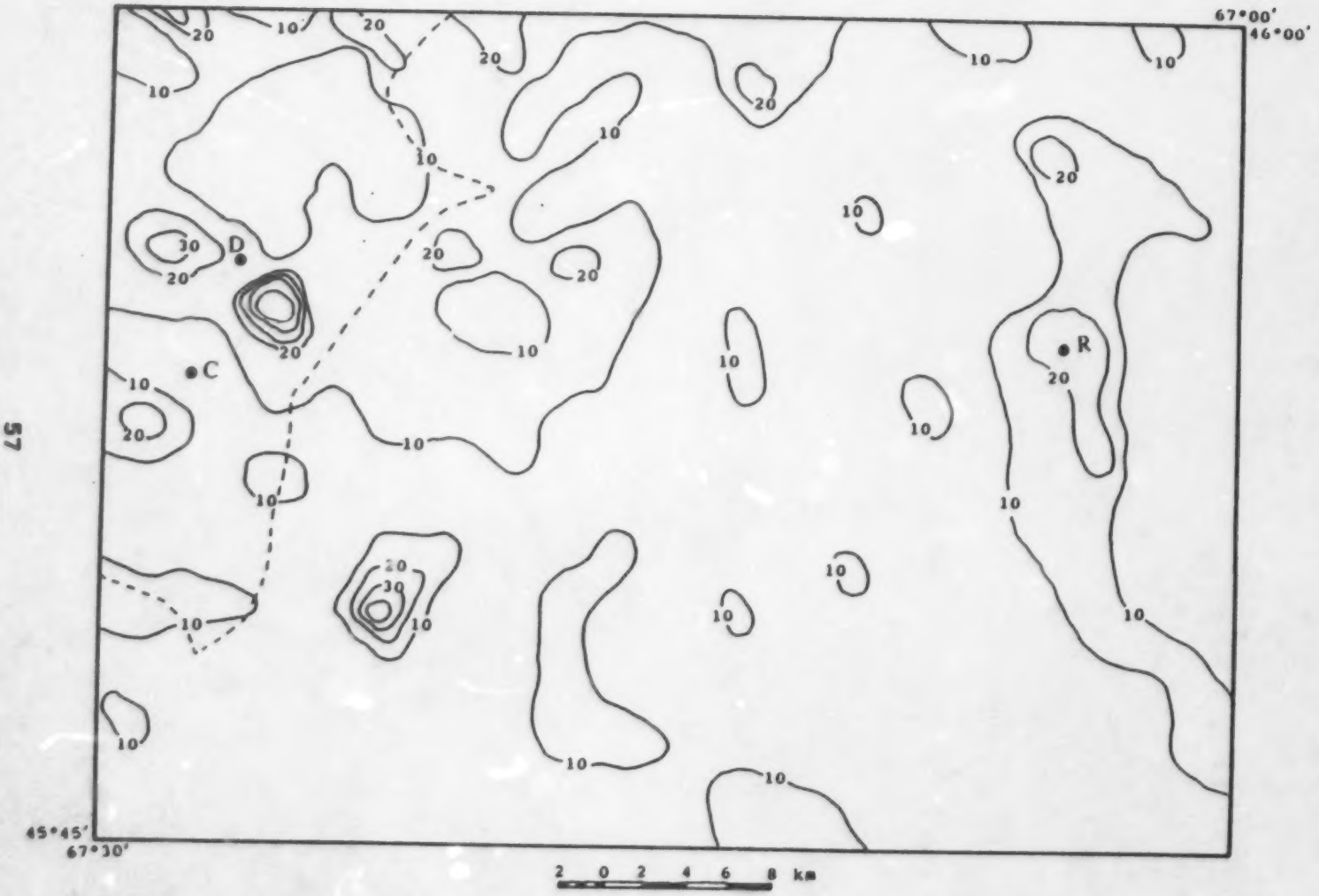

67°00'
46°00'
45°45'
67°30'
D
C
R
10
20
30
2 0 2 4 6 8 km

Figure 5.5 Dispersal pattern of granite in the matrix. Ranking determined by visual estimation. Pokiok Batholith occupies the central portion between the dashed lines.

1- dominantly granite, minor metasediments

2 - dominantly granite, some metasediments

3 - mixed

4 - dominantly metasediments, some granite

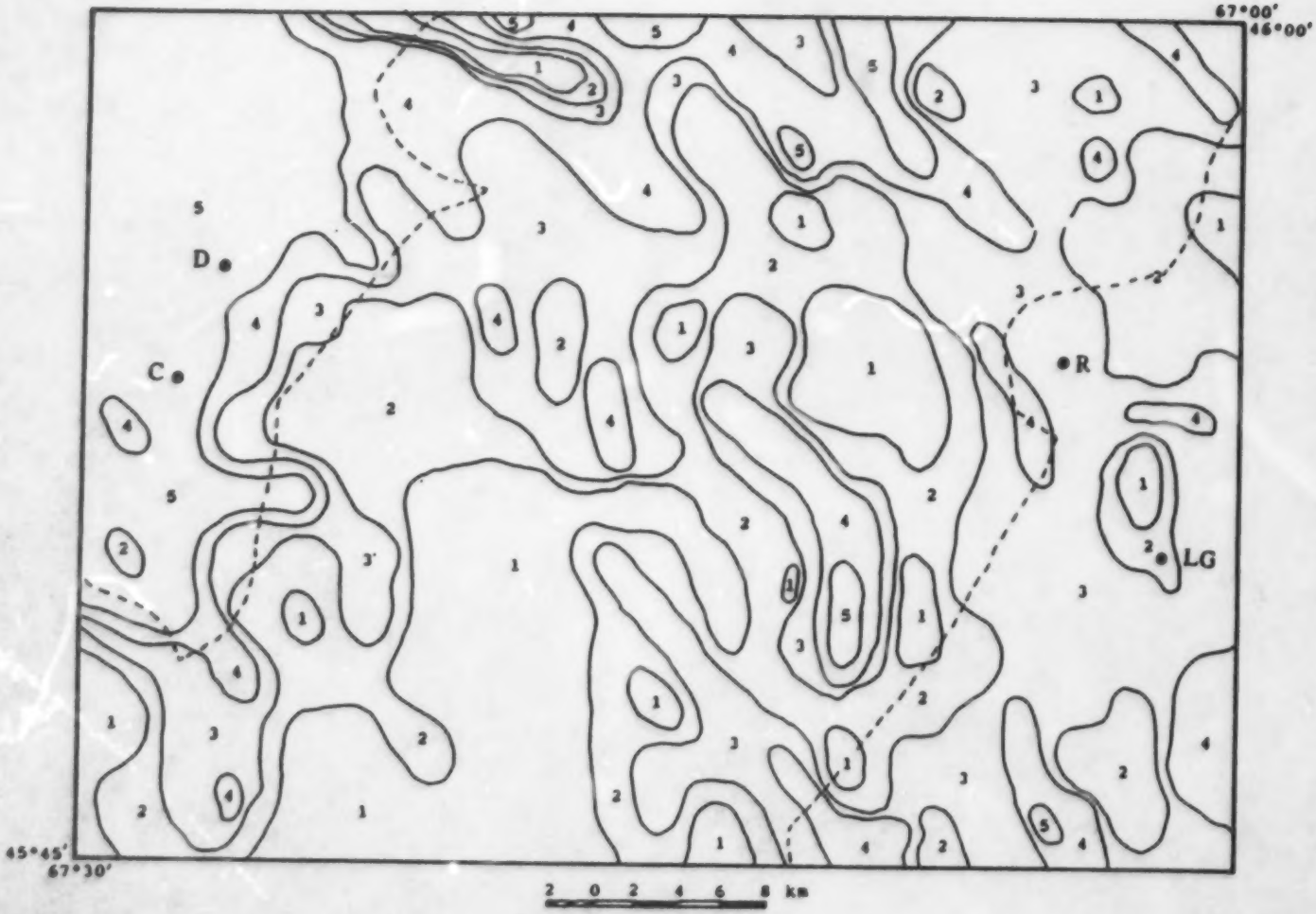
5 - dominantly metasediments, minor granite

C - Canterbury

D - Dorrington Hill

LG - Lake George

R - Rosborough Settlement


67°00'
46°00'
D
C
R
LG
45°45'
67°30'
2 0 2 4 6 8 km

5.3.1 Sand/silt/clay Ratios

Most tills in the study area possess approximately equal amounts of sand and silt, with much lower amounts of clay in their matrices (Figure 5.6). Samples near glaciofluvial deposits and granite topographic highs possess elevated sand contents (Figure 5.7), but are variable in silt, and low in clay (<5%).

The Dorrington Hill Till contains sandy-silt to silty-sand, with variable clay content (<20%). Sand contents peak near glaciofluvial deposits along the Saint John River and the eskers, south of Canterbury.

The matrices of the Hammond Brook and Lake George tills are granulometrically comparable (Figure 5.6). They contain sandy-silt, silty-sand or loam. Samples high in sand content (>50%) and low in clay (<10%) are associated with the esker near Harvey Lake.

Varying sand/silt/clay ratios were recorded in the Pokiok Till. This till contains either sandy-silt, with a high percentage of clay (up to 30%), or sand with a moderate amount of silt and minor clay (<5%). Higher silt and clay concentrations (Figure 5.8) parallel the Saint John River and form a linear band elongated towards Magaguadavic Lake.

5.3.2 Graphic Statistics

Tills in the study area exhibit little statistical variation. Grain-size studies of their matrices indicate that the tills are homogeneous over most of the area. Glaciofluvial sediments possess distinct grain-size characteristics.

The average overall grain size (Mz) of till ranges from a medium-coarse silt to a very-fine sand (5.5 - 3.0 phi). Glaciofluvial deposits are generally coarser (<3.0 phi).

Inclusive Graphic Standard Deviation reveals little difference in the degree of sorting of glacial sediments. Tills are very poorly-sorted (2.0-4.0 phi) and glaciofluvial sediments are moderately well-sorted.

Graphic kurtosis indicates that most samples have mesokurtic distributions (uniform sorting in tails and body of curve). Leptokurtic distributions (better sorted body) are associated with eskers and outwash systems. The significance of kurtosis in glacial sediments is uncertain.

5.4 Geochemistry

Background limits for geochemical elements were defined as the threshold limits determined by using the Cumulative Curve Method. Values over the background limit are considered anomalous. Elements rarely exceed background limits for the region. Those that do, plot as weak anomalies with irregular dispersal (Table 5.1). Contour plots by a computer program (SURFER®) indicate anomalous peaks for some elements in the

Figure 5.6 Sand/silt/clay ratios of the tills and glaciofluvial sediments.

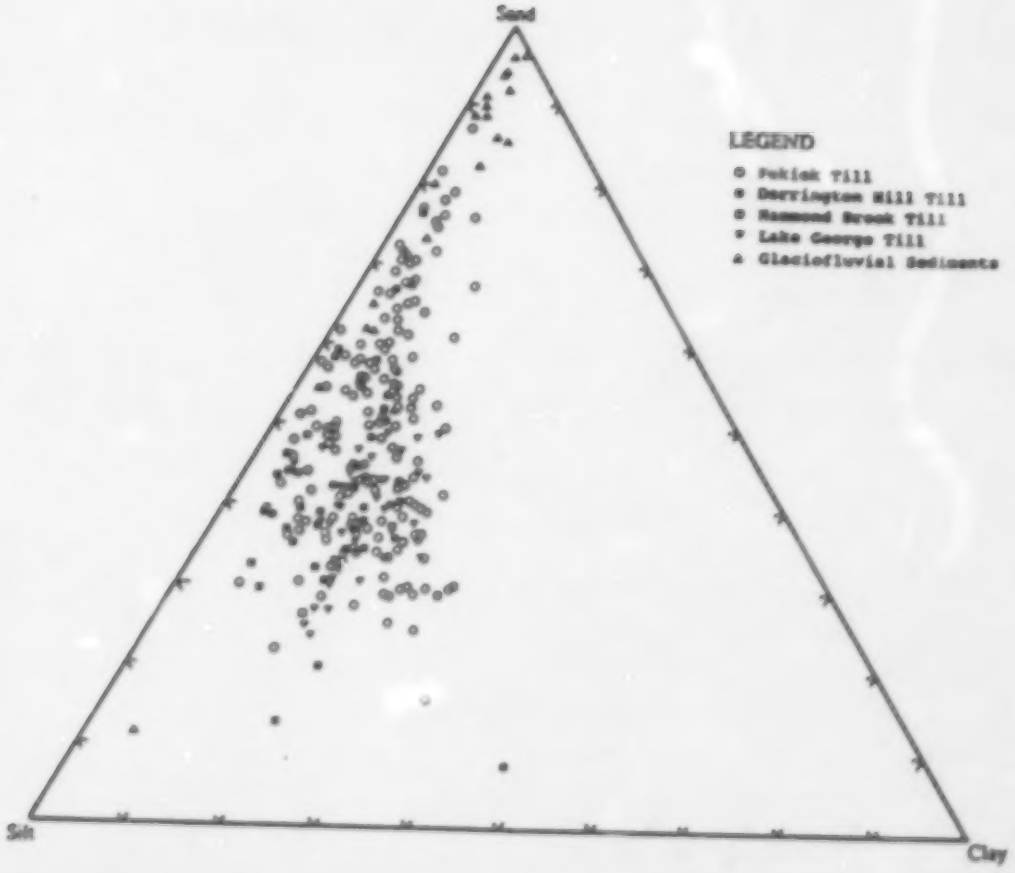

Sand
Silt
Clay
LEGEND
Pokiok Till
Derrington Hill Till
Hammond Brook Till
Lake George Till
Glaciofluvial Sediments

Figure 5.7 Dispersal of sand in matrices of samples. Contour interval is 10 %. (Contoured by hand).

C - Canterbury

D - Dorrington Hill

M - Magaguadavic Lake

R - Rosborough Settlement

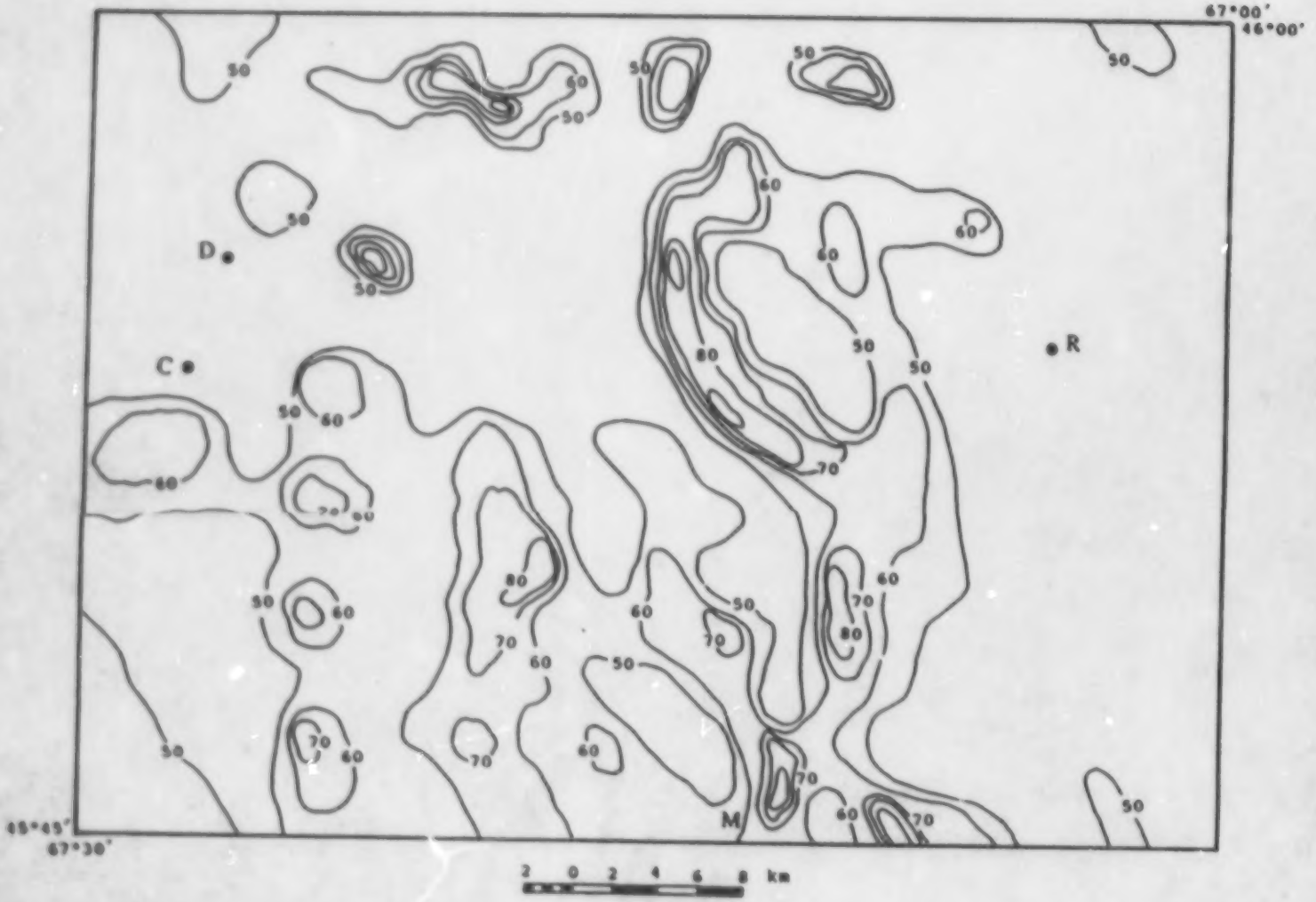

67°00'
46°00'
45°45'
67°30'
D
C
R
M
50
60
70
80
2 0 2 4 6 8 km

Figure 5.8 Dispersal pattern of clay in sample matrices.
Contour interval is 10 %. (Contoured by hand).
C - Canterbury
D - Dorrington Hill
M - Magaguadavic Lake
R - Rosborough Settlement

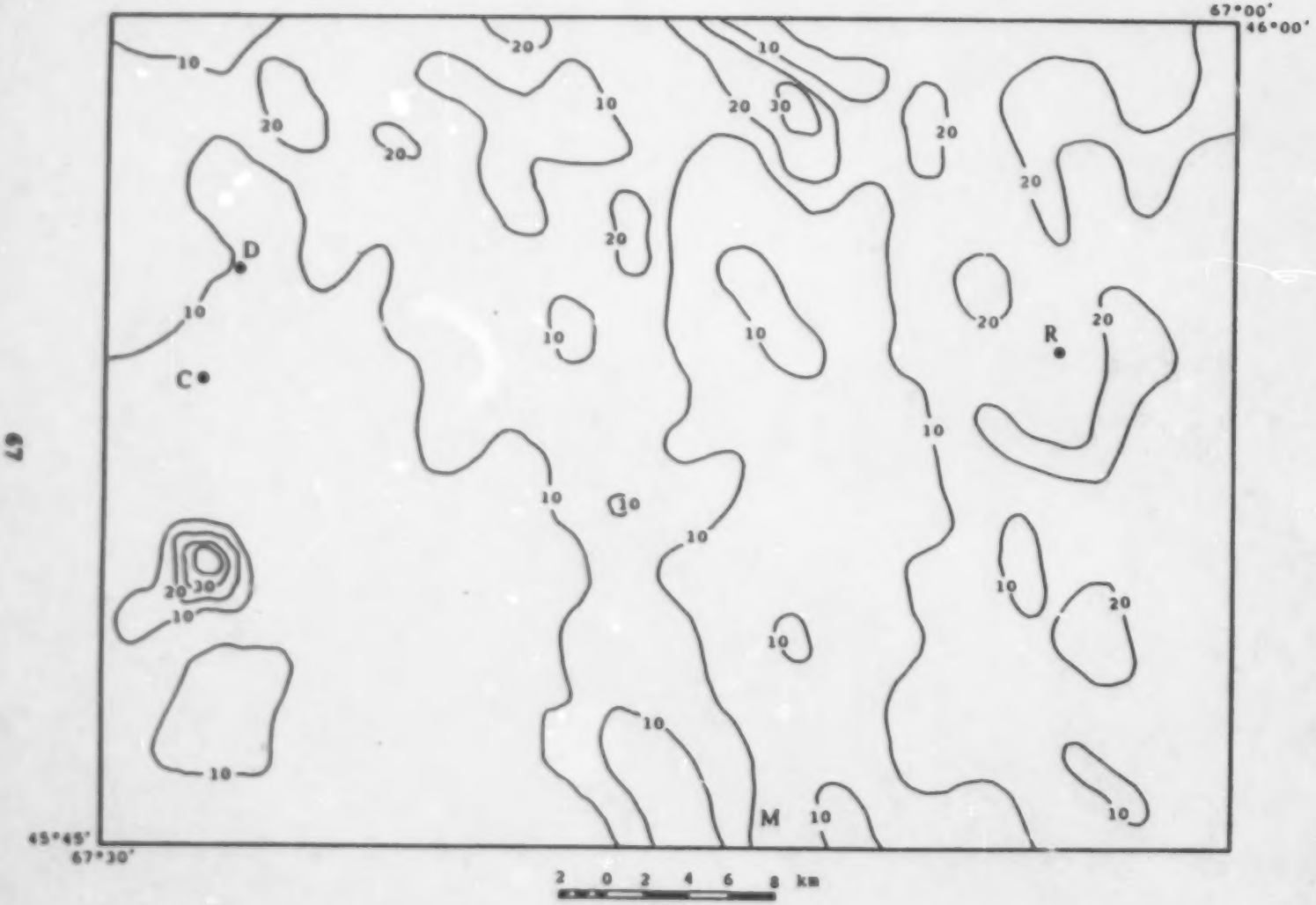

67°00'
46°00'
45°45'
67°30'
D
C
R
M
10
20
30
2 0 2 4 6 8 km

Table 5.1 Background limits for specific elements.

Element	Background (ppm)	Maximum (ppm)
Ag	0.7	2.4
As	45	250
Au*	4	46
Ce	160	270
Cr	110	180
Cu	45	75
Hg	120	260
La	70	110
Mn	1600	2100
Mo	4	10
Ni (A.A.S.)	80	120
Ni (I.N.A.A.)	120	210
Sb	1.8	31
Ta	2.5	3.3
Tb	1.3	2.9
Th	30	65
U	9	15
W	5	8
Yb	6.0	8.5
Zn (A.A.S.)	100	140

* - Value in ppb
A.A.S. - Atomic Absorption Spectrometry
I.N.A.A. - Induced Neutron Activation Analysis

study area, but give little representation of elongation trends. This is a function of the program's statistical and contouring limitations. Hand-contoured plots reveal dispersal trains elongated to the southeast. These dispersal trains are narrow and short (<six kilometres). High values are present, with areal distribution rarely exceeding a distance of two kilometres.

Anomalous values of gold (Figure 5.9), arsenic (Figure 5.10), and antimony (Figure 5.11) are centred over the Lake George Mine site. These elements form a dispersal train elongated towards the southeast. Their occurrence reflects the mineralization at the mine (Caron, oral personal communication, 1991).

Anomalous values of gold and silver (Figure 5.12) are found near the metasediment/granite contact. They occur in narrow dispersal trains, elongated towards the southeast and south. A large silver anomaly occurs near diabase units, northeast of Canterbury.

There are three sites in the study area containing coincident elemental anomalies: south of Charlie Lake; at Mud Lake along the Pokiok Esker; and, southeast of pegmatite outcrops near Cranberry Ridge. The elements include: cesium, molybdenum, cerium, rubidium, tantalum, tungsten, uranium, thorium, lanthanum, ytterbium, and neodymium.

Figure 5.9 Gold dispersion in the study area. Contour interval is 4 ppb. (Contoured by hand). Metasediment/granite contact represented by the dashed line. Granite lies to the southeast of the contact.

C - Canterbury

D - Dorrington Hill

LGm - Lake George Mine

R - Rosborough Settlement

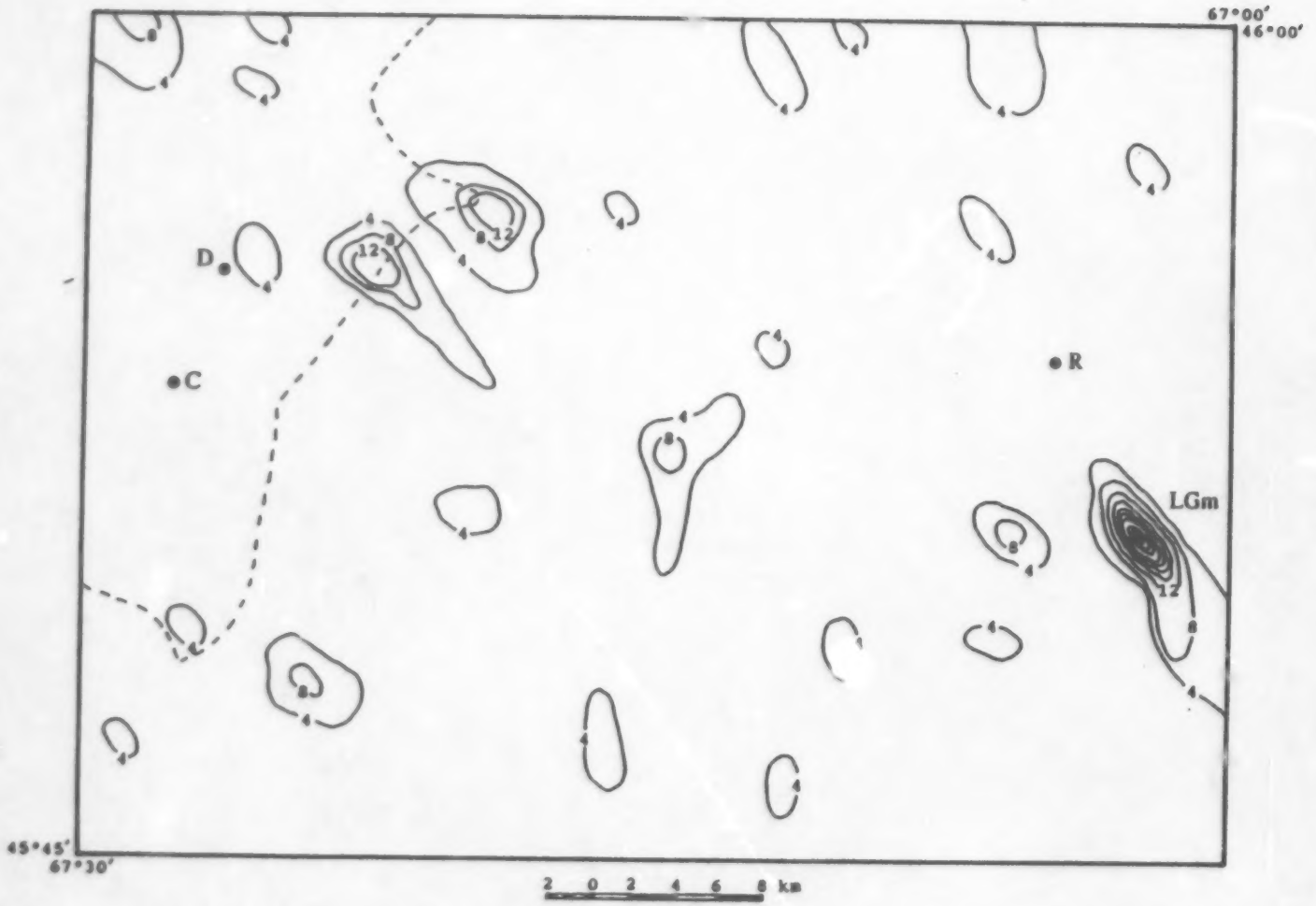

67°00'
46°00'
D
C
R
LGm
12
8
4
45°45'
67°30'
2 0 2 4 6 8 km

Figure 5.10 Arsenic dispersion in the study area. Contour interval is 50 ppm. (Contoured by hand.)

C - Canterbury

D - Dorrington Hill

LGm - Lake George Mine

R - Rosborough Settlement

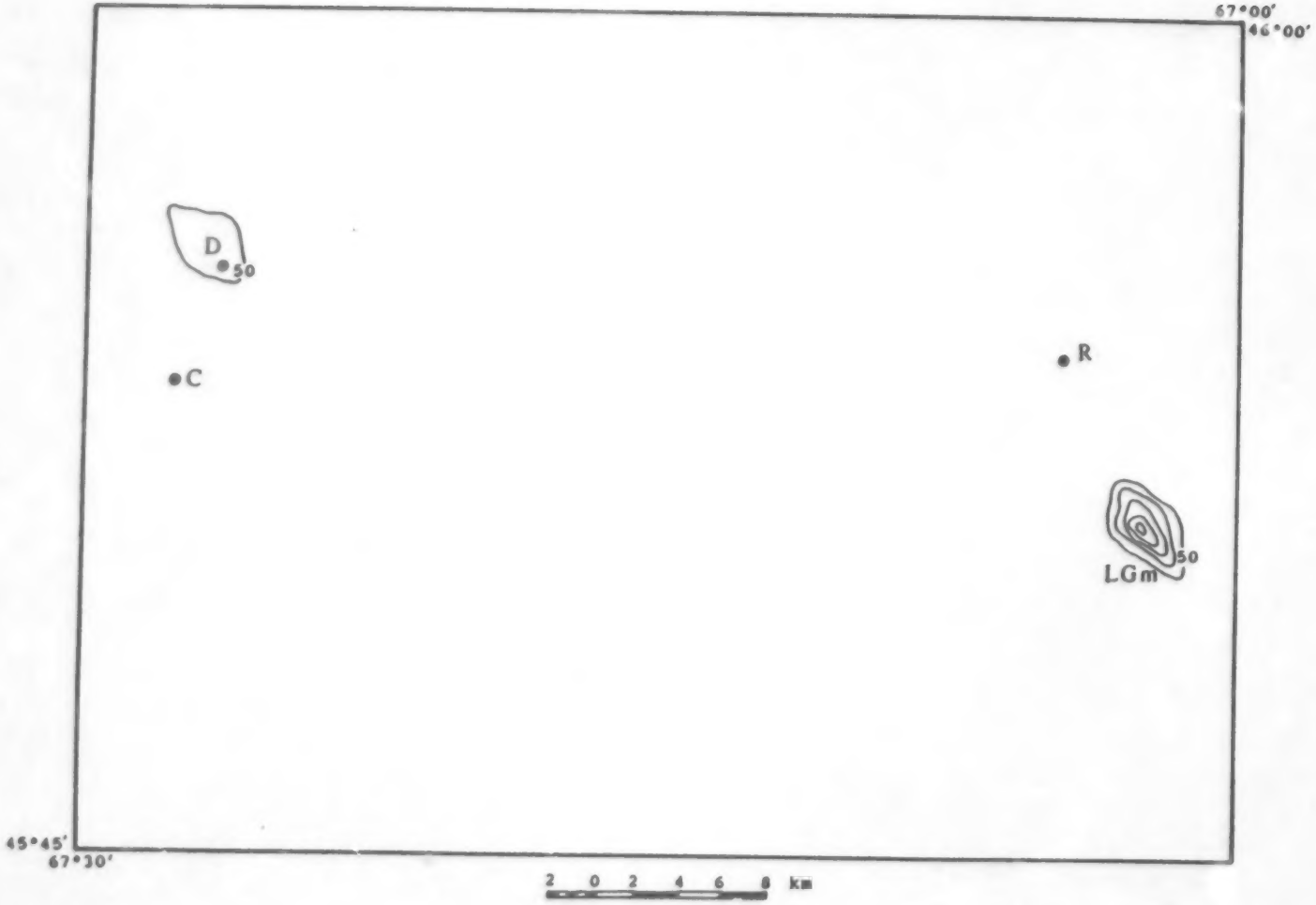

67°00'
46°00'
D
50
C
R
LGm
50
45°45'
67°30'
2 0 2 4 6 8 km

Figure 5.11 Antimony dispersion in the study area. Contour interval is 2 ppm. (Contoured by hand).

C - Canterbury

D - Dorrington Hill

LGm - Lake George Mine

R - Rosborough Settlement

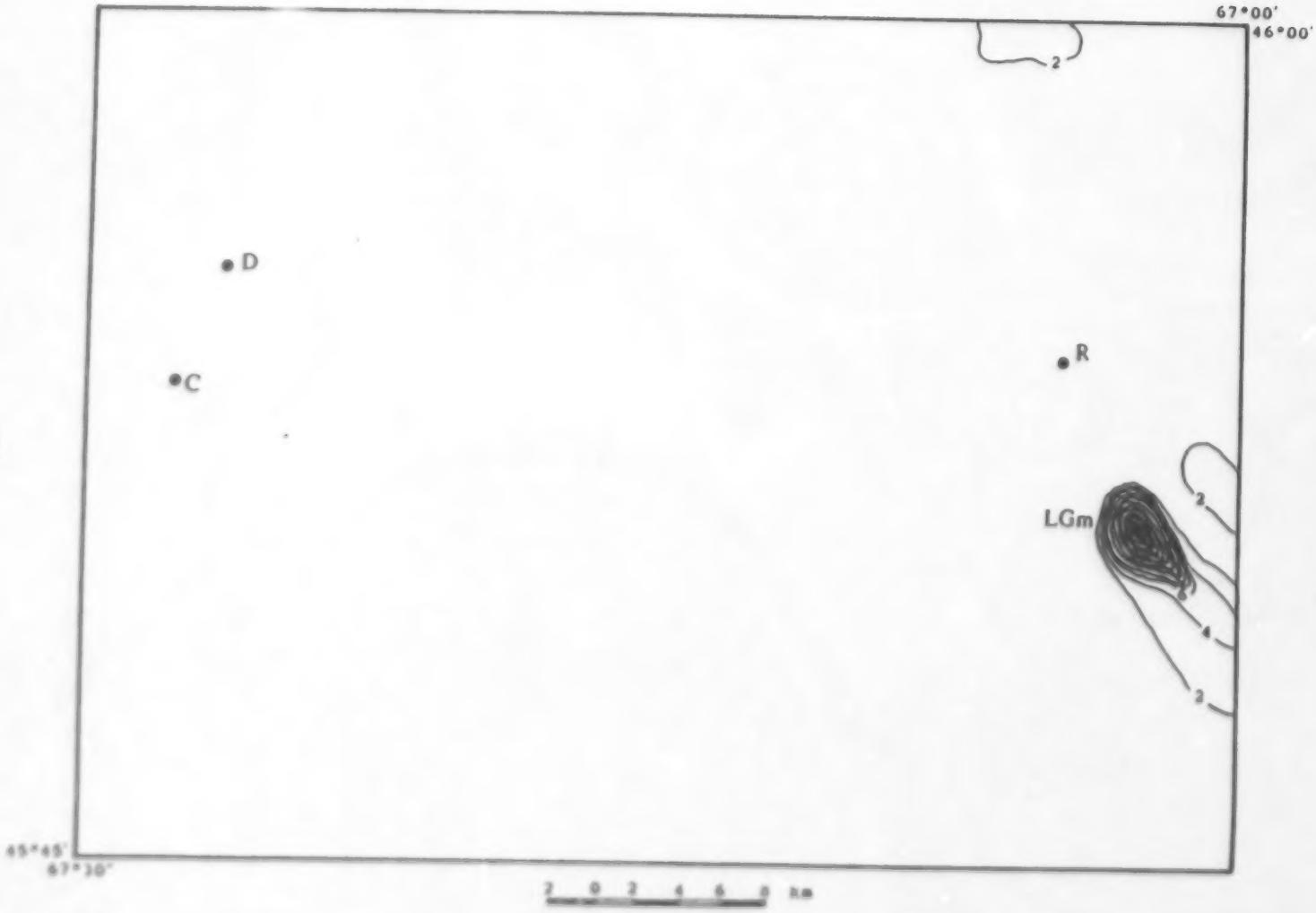
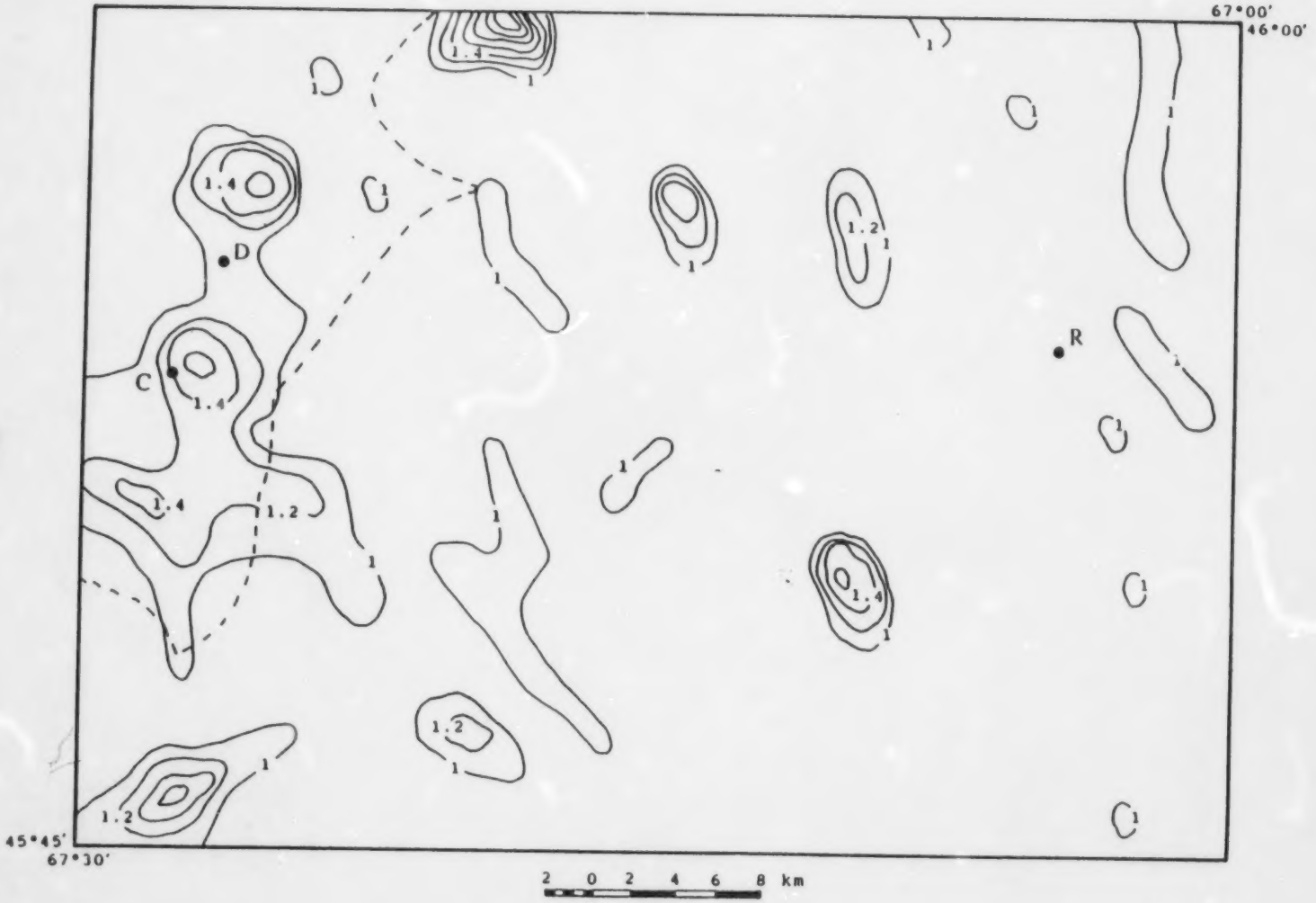

67°00'
46°00'
2
D
C
R
LGm
2
3
4
2
45°45'
67°30'
2 0 2 4 6 8 km

Figure 5.12 Silver dispersion in the study area. Contour interval is 0.2 ppm; minimum contour is 1.0 ppm. (Contoured by hand). Metasediment/granite contact represented by the dashed line. Granite lies to the southeast of the contact.

C - Canterbury

D - Dorrington Hill

R - Rosborough Settlement


67°00'
46°00'
45°45'
67°30'
D
C
R
1.4
1.2
1
2 0 2 4 6 8 km

Certain elemental contents are elevated in tills overlying particular bedrock types. Chromium and nickel values are highest in till overlying the metasedimentary units in the northwest. Molybdenum, cerium, tantalum and zinc are highest in till overlying the granites and the tonalite.

The Pokiok Esker locally contains anomalous values of copper and manganese. These dispersal patterns are elongated parallel to the esker orientation.

CHAPTER 6

DISCUSSION

The study area was glaciated during the Late Wisconsinan as evidenced by the presence of glacial sediments and erosional features. Glaciation can be separated into two styles based on directional indicators, glacial dispersal and landform morphology; a preliminary advance of a thin ice lobe along the Saint John River Valley and a subsequent advance of a thicker, regional ice sheet over the valley and higher plateau areas.

Material in the till was incorporated locally, and reflects short transportation distances. Till in the study area can be divided into four lithofacies, represented by the dominant lithology in the clasts and matrix, herein referred to by geographical location. Well-defined, anomalous dispersal patterns are topographically controlled.

6.1 Ice-Flow Patterns

Directional indicators mapped by the author are comparable to those noted previously in the area by others (Chalmers, 1885, 1886, 1902; Lee, 1962; Gadd, 1973; Rampton et al., 1984; Seaman, 1989, 1991; Seaman and Broster, 1990; Broster and Seaman, 1991).

Two directions of ice movement are inferred by the author in the study area. They consist of a dominant, southeastern

trend and a weaker, southern orientation. These directions are based on glacial erosional features on bedrock surfaces, and dispersal patterns of clast and matrix components in the surficial sediments (Map 92-68).

The earliest, and strongest, ice-flow direction was to the southeast, paralleling the main trend of the Saint John River Valley. Glacially modified physiography in the area is streamlined in this direction. Glaciated outcrops of the Carboniferous unit, near Rosborough Settlement (Figure 4.1, Map 92-68)), reflect a gradual change from the dominant southeasterly flow to a southerly direction. The subsequent, southerly ice-flow direction appears to be regional, but its erosional effects are less distinct. In most outcrops, this direction is represented by moderate to fine striae, cross-cutting earlier, southeasterly trending striae and rat tails. This cross-cutting relationship is not considered to reflect two separate ice-flow events. Rather, a single ice-flow event is likely to have undergone a change in direction later in its development.

Ice flow patterns east and southeast of the study area may have been influenced by the Gaspereau Ice Centre (Seaman, 1991; Gadd, 1973; Rampton et al., 1984). Interference by ice flow from this ice cap could have blocked the southeasterly ice flow, causing it to curve south towards the Bay of Fundy. This would require that ice over the study area was thin enough to be diverted by local ice caps and could also have

been subject to the influence of physiographic controls. The lack of distinct and separate dispersal patterns for the two ice-flow directions is evidence against an ice-divide in the study area.

Dispersion plots for clast and matrix components of the glacial sediments in the study area support southeasterly and southerly flow directions. Northwest of the metasediment/granite contact, granite is rare to absent as either matrix components, or as clasts or surface boulders. Granite clasts in till increase in samples located progressively southward of the contact. Clasts from Silurian sedimentary units in the southeast do not extend northward into the area underlain by granite. This evidence precludes northward or northwestward ice-flow in the area.

6.2 Dispersal Patterns

Dispersal analyses, using clast lithology and geochemistry of glacial sediments, have been used as an exploration tool in Europe (Kauranne, 1958, 1959) and Canada (Shilts, 1976, 1984; McConnell and Batterson, 1987; Coker and DiLabio, 1989; DiLabio, 1990).

According to Shilts (1976), well-defined dispersal trains are finger- or ribbon-shaped. Variations in their morphology can be attributed to changes in ice-flow direction, physiographic influences or multiple ice-flow events. He suggested (Ibid., 1976) that dispersal trains, classified

according to shape and concentration (Table 6.1), can be used to plan follow-up exploration programs designed to define potential targets. Types 3A, B and C (Table 6.1) are considered high priority anomalies, with nearby sources. Types 2A, B and C have lower priority, with indeterminate sources. Types 1A, B and C have the lowest priority for exploration. The latter types are poorly defined, small and difficult to interpret.

This classification scheme works best for geochemical data. Anomalous dispersal patterns based on clasts can be difficult to classify. In areas where there are only a few rock units, distinctive lithologies are easier to trace and classify. However, dispersal patterns based on broader lithologic groups can not be properly classified according to Table 6.1. Broader lithologic groups, with multiple sources, may form combined dispersal patterns as in the present study.

6.2.1 Clast Dispersal Patterns

In the study area, clasts are dispersed as elongated trains, 8 to 10 kilometres in length, and as wide bands parallel to bedrock contacts. Individual clast and group lithologies (aplite, granite and volcanic) are traceable as well-defined dispersal trains trending southeast and south. Aplite clasts form 2B and 3B type dispersal anomalies (Figure 5.1) suggesting that transportation distances of the material

Table 6.1 Anomaly classification.*

CONCENTRATION	
1	Anomalies consisting of one or two adjacent samples with values just above the regional background.
2	Anomalies covering several square miles with values ranging from just above background to four times background.
3	Anomalies comprising one or two adjacent samples whose values are five or more times background.
AREAL SHAPE	
A	Amoeboid, irregular or isotropic.
B	Strongly elongated in the direction of glacial movement.
C	Strongly elongated in the direction of bedrock strike.

* Shilts (1976)

is short. Possible sources for most of the dispersal trains in till occur within three kilometres of the trains.

Certain clast components (volcanics and granites) decrease in number within a few kilometres of bedrock contacts (Figures 5.1 and 5.2). Granite clasts and boulders were not found in the northwestern portion of the study area. The abundance of this lithology in the southeast supports ice-flow in this direction.

Sources for clasts forming dispersal trains associated with glaciofluvial deposits are enigmatic. Smaller eskers contain mainly local material. The Pokiok Esker contains a mix of lithologies, of which approximately half has been locally derived (Figure 5.2). Glaciofluvial deposits may obtain material from multiple sources and are therefore poor indicators of provenance. However, they can indicate if glaciofluvial materials have been contributed mainly from higher positions in the ice and thus more distal lithologies, or subglacially and thus more local lithologies.

6.2.2 Matrix Dispersal Patterns

Most elements are homogeneously distributed across the study area, except near known mineral occurrences and topographic highs. Geochemical anomalies are only slightly above background limits and restricted in extent. Matrix dispersion anomalies are narrow and short in length (2-5 kilometres). These anomalies (See Table 6.1) are described as

types 1A, 1B, 2B and 3B. Little information can be infered from the Type 1 anomalies. The 2B- and 3B-type anomalies are elongated towards the southeast and south, paralleling local ice-flow directions. These well-defined anomalies occur on topographic highs suggesting that incorporation of material by grounded ice was better in those areas. Shilts (1976) suggested that sources for 2B and 3B types usually occur near the up-ice end of the anomalies. This would suggest that glacial transportation of the material was short (e.g. less than 5 kilometres).

Geochemical anomalies are observed near known mineral occurrences in the area. The best example of dispersion occurs at the Lake George Mine. Antimony, gold and arsenic form well-defined 3B anomalies elongated towards the southeast (Figures 5.9, 5.10 and 5.11). These trains (DiLabio, 1990) disperse towards the south into areas of lower elevation.

The high proportion of peat bogs and swamps in the study area must be considered in geochemical analyses. Many of the bogs are minerotrophic (Keys and Henderson, 1983) and thus concentrate elements transported in from the surrounding sediments. Higher values of metallic elements are often associated with the margins of these bogs (Rose et al., 1979). Small anomalies (Type 1) occur near the bogs in the study area that may have originated in this manner.

During transport, minerals have minimum grain-sizes (terminal grades) to which they can be physically reduced

(Dreimanis and Vagners, 1971). Accordingly (Ibid., 1971), grain size is reduced as distance of transport increases; however, minerals are not reduced indefinitely. The mineralogy of local bedrock should be reflected in coarser grain-sizes because of terminal grade. However, while finer-grained clay and silt may be more representative of material derived from great distances, it can also be incorporated as pre-glacial unconsolidated silt or clay (Broster, 1982). This may account for the poor correlations found between geochemical and clast data (See section 6.2.3).

Tills are better sorted in the study area than the range of values given by Folk (1974). The improved sorting of the till may have resulted from the incorporation of material already reduced to terminal grades, such as grus and/or pre-existing deposits of unconsolidated sediments. Reworking by surface runoff or meltwater has probably contributed also to the improved sorting of the tills.

Granulometric analyses of till indicate minor statistical variation between the four till facies members: the Pokiok, Dorrington Hill, Hammond Brook, and Lake George. Lateral homogeneity of granulometric parameters between samples implies deposition from the same ice source (May and Dreimanis, 1976). The granulometric parameters of the four till members in the study area are laterally homogenous and therefore probably represent a single till unit. The only

differences between members, discussed further in a later section, are lithology and occasionally colour.

6.2.3 Significance of Dispersal Patterns

May and Dreimanis (1976) suggested that pebble lithologies are more variable than granulometric parameters and thus matrices are inherently more homogeneous as a whole. Dispersal patterns for clast and matrix components in the study area supports this statement. Dispersion patterns of geochemical anomalies are small and indistinct compared to dispersal trends derived from clast lithology analyses. Aplite, granite and volcanic clasts are easily identified and traceable over broader areas.

Most geochemical dispersion patterns in the study area provide little information about anomaly sources or ice-flow directions. Major anomalies are associated with mineralization at the Lake George Mine. The morphology and size of dispersal patterns do not appear to be related to any specific bedrock type, except diabase. Large gold and silver anomalies occur in till near the metasedimentary/granite contact and the Dorrington Hill, Canterbury and Lake George settlements (Figure 3.1). The first three areas occur near diabase units.

Elongation in the direction of ice-flow is more pronounced for clast dispersal patterns than for geochemical data. Well-defined clast-dispersal patterns appear to occur on topographic highs (types 2B and 3B), while at lower

elevations, dispersal patterns are rarer and less distinct (types 1A and 1B). This has previously been reported by Hornibrook et al. (1991), who suggested that it is a function of preferential glacial erosion at topographic highs.

The size of the initial sampling grid influences the morphology of dispersal anomalies. A 2 km^2 sampling grid suffices for clast analyses in the study area because their dispersal patterns are broader and thus easier to identify. Most geochemical dispersion anomalies in the study area are small and defined by one to three sample sites. Shilts (1976) indicated that geochemical analyses using large sampling grids rarely gave accurate dispersal patterns. More detailed sampling at closer intervals is needed to properly define geochemical anomalies.

The abundance of local material in matrix and clast fractions of the sediments, and the rapid change of lithology near contacts, reflect short transportation distances.

6.3 Style of Glaciation

The preservation of extensively weathered bedrock, that apparently predates the Late Wisconsinan, has previously been interpreted as evidence of non-glaciation (Rampton et al., 1984). In the study area, evidence of glaciation is seen in the form of extensive glaciofluvial deposits, basal till overlying weathered bedrock, and glacially eroded features (Map 92-68).

The four basal till members (Pokiok, Dorrington Hill, Hammond Brook, and Lake George) likely represent lithofacies of one till deposited during a single ice-flow, rather than distinct units of different events. All four tills have similar median grain-size, sorting, skewness and kurtosis values. Sand/silt/clay ratios indicate that the Hammond Brook, Lake George and Dorrington Hill lithofacies contain high proportions of silt and clay in their matrices (Figure 5.6). The Dorrington Hill member is separated from the other two members by slightly higher sand content and its geographic location. The Pokiok member is siltier near its northwestern contact with the Dorrington Hill Member and along the Saint John River, but is sandier elsewhere. The lateral homogeneity of granulometric parameters amongst the till members suggests deposition from the same ice source (May and Dreimanis, 1971). Geochemical components are relatively homogeneous across the tills, with the exception of a few elements (gold, silver, arsenic and antimony).

The dispersal pattern of matrix lithology closely follows bedrock lithology. The four till members are identified by their dominant lithology and underlying bedrock type (Map 92-68). However transitional zones between the tills were observed as gradational changes between lithologies. Changes in lithologies are not abrupt or interfingered, as would be expected if the members were generated by separate events. The

gradual change in lithology between till members suggests that these members are likely lithofacies of a single till.

The presence of lithofacies with gradational contacts in the till has implications on the style of glaciation in the study area. Maritime climates commonly produce fast-moving glaciers, with larger volumes of ice and glacial meltwater (Sugden and John, 1976). The study area is located in a maritime climate, controlled by oceanic influences. The climate is generally warmer due to heat regulation by the ocean. This increases the surface temperature of glacial ice, producing high volumes of meltwater runoff. Meltwater in turn heats the ice and produces warm-based conditions, accelerating the flow rate.

Glaciers in such an environment would undergo rapid drawdown and thinning, resulting in higher deglaciation rates. Confinement of ice to large channels (e.g. Saint John River Valley) may accompany deglaciation, producing ice streaming associated with valley-confinement and overriding of deformable subglacial sediments.

Glacigenic rafting is observed within three kilometres of the contact between metasedimentary rocks and granite. This change in bedrock type may have influenced the basal thermal regime. Glacigenic rafting of highly weathered grus suggests freezing of the material under a cold-based glacier (Broster and Seaman, 1991). Yet, the terrain near these sites indicates glacial erosion, which should not occur under cold-based

conditions (Sugden and John, 1976). The author attempted to resolve this conflict by airphoto interpretation and ground-truth investigation of the area surrounding the glacigenic rafting. These studies did not reveal the presence of any features (e.g. polygonal ground patterns and ice wedges) associated with cold-based glaciers and permafrost conditions. This negative information suggests that if cold-based conditions existed during glacigenic rafting, they were very localized.

The rafting may have resulted from freeze-thaw entrainment occurring under mixed warm- and cold- based conditions, as suggested by Broster and Seaman (1991). The highly porous grus could trap meltwaters and become frozen under periglacial conditions. Slabs of this material are then entrained at the base of the ice. This would imply different styles of erosion between granite and other lithologies. No obvious difference in the style of erosion is seen. However, it was observed that the granite was rapidly incorporated in the matrix of till near the metasediment/granite contact.

Thus it is likely that the four till lithofacies represent the interrelationship between subglacial materials and glacier dynamics. Specifically, the Pokiok member likely represents areas of slow moving ice, with periodic freezing to the granite substrate and subglacial thrusting. The Hammond Brook member appears to be a result of incorporation of preglacial unconsolidated sediments and ice streaming along

the Saint John River Valley. The exact interaction between subglacial erosion and ice dynamics for the other till members is not known.

In general, complete mixing was achieved within five kilometres of contacts for matrix and 10 kilometres for clasts. The rapid switch in lithology and texture of the underlying bedrock may have induced changes in the basal thermal regime of the ice during glacial advance that facilitated compositional homogenization. These features are important as evidence of advance of grounded ice in the plateau areas under subaerial conditions.

6.4 Style of Deglaciation

The lack of distinct end moraines, widespread occurrence of stagnation moraine and abundant ice-contact deposits, suggest that the area underwent rapid deglaciation (Map 92-68). Ablation and ice-contact features (e.g. eskers, kames, kame-delta) are common, particularly at higher elevations along the Saint John River Valley. Their occurrence and orientation, often crossing valleys and not terminating at the Saint John River, indicate that these plateau areas were deglaciated prior to ice ablation in local valleys. For example, the Pokiok Esker crosses the Saint John River (Map 92-68), requiring that the river valley was occupied by either glacial sediments, or an ice-lobe, in the early stages of deglaciation.

Kame delta deposits along the Saint John River near Nackawic (Map 92-68) are interpreted as indicating proglacial ponding during deglaciation of the valleys. Glaciofluvial and glaciolacustrine deposits are not found beyond the high terraces along the Saint John River, suggesting that proglacial ponding was confined to the river valley and resulted from the retreat of valley-contained ice lobes. During retreat, large quantities of glaciofluvial sediments were deposited in the river valley.

CHAPTER 7

CONCLUSIONS

Ice overlying the Canterbury map area underwent rapid deglaciation and stagnation during the Late Wisconsinan. Directional indicators, paleocurrent measurements and dispersal patterns indicate two ice-flow orientations. The earliest and most dominant flow was to the southeast. This direction is overprinted by a weaker and less erosive flow to the south. These directions are conformable to the Woodstock ice-flow pattern during the Millville/Dungarvon Phase (12.7 to about 12.3 ka). The lack of two or more distinct and separate ice-flow directions suggests that no ice divide existed in the study area. The southeast and southerly trends correspond to directions observed west and north of the Canterbury area. No evidence for northward ice-flow was observed.

Clast and geochemical dispersal patterns are better defined on topographic highs. Clast dispersal trains are elongated in a southeasterly direction, with southward overprints, up to 10 kilometres in length. Geochemical anomalies are localized, less than five kilometres in length, with values only slightly above background limits. They rarely provide information on glacial dispersion and transportation distances. Well-defined geochemical anomalies occur near known mineral occurrences.

Granulometric analyses indicate that the tills are homogeneously mixed. Distance of transport is apparently short, about 10-15 kilometres, and does not appear to be the cause of sorting in the tills. Terminal grade of the minerals in the bedrock influences sorting by its effect on grain size distribution.

From the homogeneous nature of till in the study area, it is inferred that the different till members identified by surficial mapping were the product of a single ice-flow event. Variations in the till lithofacies are attributed to interactions between ice and different bedrock lithologies. The lack of multiple till exposures in the plateau areas suggests that surficial erosion and deposition are likely the products of a single ice-flow event.

There is a lack of evidence for cold-based thermal conditions, other than glacigenic rafting. The abundance of erosional features and glaciofluvial deposits, and evidence of rapid deglaciation, supports grounded ice under warm-based thermal regimes thus subglacial freezing is likely due to local variations in the basal thermal regime (Broster and Seaman, 1991), rather than a proglacial permafrost climate.

Areas of higher elevation underwent rapid deglaciation resulting in the deposition of stagnation moraine across most of the study area. Meltwater channels were catastrophic and limited in duration, forming boulder lags in some of the stream valleys. Ice during the final stages of deglaciation

was restricted to lobes occupying the Saint John River Valley. Incision of the sediments of the Saint John River Valley continues at present, although probably initiated during glacial retreat.

REFERENCES

Anonymus, 1953. Canterbury, York and Carleton Counties, New Brunswick. Geological Survey of Canada, Aeromagnetic Series, Map 145 G, scale 1:50 000.

AYLSWORTH, J.M. and SHILTS, W.W. 1987. Surficial geology, Coats Island, District of Keewatin, Northwest Territories. Geological Survey of Canada, Map 1633A, scale 1:125 000.

AMERICAN SOCIETY FOR TESTING AND MATERIALS. 1964. Procedures for testing soils. 4th ed. Philadelphia, Pennsylvania.

ANDERSON, F.D., and POOLE, W.H. 1959. Geology of Woodstock - Fredericton, York, Carleton, Sunbury and Northumberland Counties, New Brunswick. Map 37-1959, scale 1:126 720.

BOSTOCK, H.S. 1970. Physiographic regions of Canada; Geological Survey of Canada, Map 1254A.

BROSTER, B.E. 1982. Compositional variations in the St. Joseph till units of the Goderich area, Ontario. Ph.D. thesis, the University of Western Ontario, London, Ontario.

BROSTER, B.E., and CLAGUE, J.J. 1987. Advance and retreat glacigenic deformation at Williams Lake, British Columbia. Canadian Journal of Earth Sciences, 24:1421-1430.

BROSTER, B.E., and SEAMAN, A.A. 1991. Glacigenic rafting of weathered granite: Charlie Lake, New Brunswick. Canadian Journal of Earth Sciences, 28:649-654.

CHALMERS, R. 1885. Report on the Surface Geology of Western New Brunswick with special references to the areas included in York and Carleton Counties. Geological Survey of Canada, Report of Progress 1882-84, Part XI.

------- 1886. Preliminary report on the surface geology of New Brunswick. In Annual Report 1885, Geological Survey of Canada, v. 1, Part GG.

------- 1902. Report on the Surface Geology shown on the Fredericton and Andover Quarter-Sheet Maps, New Brunswick. Geological Survey of Canada, Annual Report 1899, Vol. XII, Part M.

COKER, W.B. and DILABIO, R.N.W. 1989. Geochemical exploration in glaciated terrain: geochemical responses. Exploration '87, Ontario Geological Survey, Special Volume 3:336-383.

DILABIO, R.N.W. 1990. Chapter 7: Glacial dispersal trains. In Glacial Indicator Tracing. Edited by R. Kujansuu and M. Saarnisto. A.A. Balkema, Rotterdam, pp. 109-122.

DREIMANIS, A. 1976. Tills: their origin and properties. In Glacial Till: An Inter-Disciplinary Study. Edited by R.F. Legget. Royal Society of Canada, Special Publication, 12:11-49.

DREIMANIS, A. and VAGNERS, U.J. 1971. Bimodal distribution of rock and mineral fragments in basal tills. In Till: A Symposium. Edited by R.P. Goldthwait. Ohio State University Press, pp. 237-250.

FOLK, R.L. 1974. Petrology of Sedimentary Rocks. Hemphill Publishing Company, Austin, Texas.

FYFFE, L.R., PAJARI, G.E., and CHERRY, M.E. 1981. The Acadian Plutonic rocks of New Brunswick. Maritime Sediments and Atlantic Geology, 17:23-36.

GADD, N.R. 1973. Quaternary Geology of southwest New Brunswick, with particular reference to Fredericton area. Geological Survey of Canada, Paper 71-34.

GRANT, D.R. 1989. Quaternary geology of the Atlantic Appalachian region of Canada. In Quaternary Geology of Canada and Greenland. Edited by R.J. Fulton. Geological Survey of Canada, Geology of Canada, No. 1, pp. 393-440. (Also Geological Society of America, Kansas University Press, Lawrence, The Geology of North America, Vol. K-1.)

HORNIBROOK, E.R.C., BROSTER, B.E., GARDINER, W.W. and PRONK, A.G. 1991. Glacial dispersion of heavy minerals in Late Wisconsinan Till: Central New Brunswick. Atlantic Geology, Vol. 27, No. 3, in press.

HUGHES, O.L. 1989. Surficial geology, Long Lake, Yukon Territory. Geological Survey of Canada, Map 20-1987, scale 1:100 000.

HUNTER, M., and LAVERGNE, C. 1982. Granular Aggregate Resources of Fosterville (21G/13) and Canterbury (21G/14). New Brunswick Department of Natural Resources, Mineral Resources Division, Open File Report 82-4 and Plates 81-81, and 81-82.

KAURANNE, L.K. 1958. On prospecting for molybdenum on the basis of its dispersion in glacial till. Commission Géologique de Finlande, Bulletin 180:31-43.

--------, 1959. Pedogeochemical prospecting in glaciated terrain. Commission Géologique de Finlande, Bulletin 184:1-10.

KEYS, D., and HENDERSON, R.E. 1983. An investigation of the peat resources of New Brunswick. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 83-10, Plates 83-10(A-F), and Map I8.

LAMOTHE, M. 1990. Overburden Drilling Program in the Saint John Valley and the Baie des Chaleurs Coastal Area of Northern New Brunswick: Till Geochemistry and Borehole Logs. Geological Survey of Canada, Open File 2149.

LEE, H.A. 1962. Surficial geology of Canterbury, Woodstock, Florenceville, and Andover Map Areas; York, Carleton, and Victoria Counties, New Brunswick (Parts of 21 G/14, 21 J/4, 21 J/5, and 21 J/12). Geological Survey of Canada, Paper 62-12 and Map 23-1962, scale 1:63 360.

LUTES, G. 1979. Geology of Fosterville - North and Eel Lakes Map-Area G-23 and Canterbury - Skiff Lake Map Area H-23 (Parts of 21G/13 and 21G/14). New Brunswick Department of Natural Resources, Mineral Resources Branch, Map Report 79-3 and Plates 79-25A, and 79-26A.

------- 1987. Geology and Geochemistry of the Pokiok Batholith, New Brunswick. New Brunswick Department of Natural Resources, Minerals and Energy Division, Report of Investigation 22 and Plates 80-101(R), and 80-102(R).

MATTHEW, G.F. 1879. Report on the superficial geology of Southern New Brunswick. Geological Survey of Canada, Report of Progress 1877-78, Part X.

MAY, R.W. and DREIMANIS, A. 1976. Compositional variability in tills. In Glacial Till: An Inter-Disciplinary Study, R.F. Legget (Editor). Royal Society of Canada, Special Publication, 12:99-119.

McCONNELL, J.W. and BATTERSDON, M.J. 1987. The Strange Lake Zr-Y-Nb-Be-REE deposit, Labrador: a geochemical profile in till, lake and stream sediment, and water. In Geochemical Exploration 1985. Edited by R.G. Garrett. Journal of Geochemical Exploration, 29:105-127.

PRONK, A.G., BOBROWSKY, P.T., and PARKHILL, M.A. 1989. An interpretation of the Late Quaternary glacial flow indicators in the Baie des Chaleurs region, northern New Brunswick. Géographie physique et Quaternaire, 43:179-190.

RAMPTON, V.N., GAUTHIER, R.C., THIBAULT, J., and SEAMAN, A.A. 1984. Quaternary Geology of New Brunswick. Geological Survey of Canada, Memoir 416 and Map 1594A, scale 1:500,000.

RAMPTON, V.N. and PARADIS, S. 1981. Quaternary geology of the Woodstock map area (21J), New Brunswick. New Brunswick Department of Natural Resources and Energy, Map Report 81-1.

ROSE, A.W., HAWKES, H.E., and WEBB, J.S. 1979. Geochemistry in Mineral Exploration, 2nd Edition. Academic Press, London, U.K.

RUITENBERG, A.A., FYFFE, L.R., McCUTCHEON, S.R., ST. PETER, C.J., IRRINKI, R.R., and VENUGOPAL, D.V. 1977. Evolution of pre-Carboniferous tectonostratigraphic zones in the New Brunswick Appalachians. Geoscience Canada, 4:171-181.

SEAMAN, A.A. 1989. Glacial Striae Trends in New Brunswick: A Compilation. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Open File Report 89-34.

------- 1991. Complex glacial ice-flow events in New Brunswick with particular reference to the Oromocto Lake area, and implications for drift prospecting. New Brunswick Department of Natural Resources and Energy, Mineral Resources, Geoscience Report 89-2 and Plate 89-11.

SEAMAN, A.A., and BROSTER, B.E. 1990. Glacial Geology of the Area Southwest of the Saint John River Valley. 40th AUGC 1990 Field Trip #1, Fredericton, New Brunswick.

SHILTS, W.W. 1976. Glacial till and mineral exploration. In Glacial Till: An Inter-Disciplinary Study, R.F. Legget (Editor), Royal Society of Canada, Special Publication, 12:205-224.

-------, 1984. Till geochemistry in Finland and Canada. Journal of Geochemical Exploration, 21:95-117.

STEA, R.R. and MOTT, R.J. 1990. Quaternary geology of Nova Scotia; Guidebook for 53rd Annual Friends of the Pleistocene Field Excursion. Nova Scotia Department of Mines and Energy, Open File Report 90-008.

SUGDEN, D.E. and JOHN, B.S. 1976. Glaciers and Landscape: A Geomorphological Approach. Edward Arnold (Publishers) Limited, London, England.

VENUGOPAL, D.V. 1979. Geology of Debec Junction - Gibson Millstream - Temperance Vale - Meductic Region Map Areas G-21, H-21, I-21, and H-22 (Parts of 21J/3, 21J/4, 21G/13, and 21G/14). New Brunswick Department of Natural Resources, Mineral Resources Branch, Map Report 79-5 and Plates 78-27A, 78-30A, 78-31A, and 78-32A.

APPENDIX I

SITE LOCATIONS

Samples taken during field mapping in the N.T.S. 21 G/14 topographic map sheet (Figure 2.1), were given letter-number codes ranging from A1 (northwestern corner of the study area) to W14 (southeastern corner). The samples were obtained on a 2 km^2 grid based on U.T.M. co-ordinates.

Samples with extra number or letter codes refer to duplicate sites (A1, So1); extra samples off the main grid (a, h, .5); or, multiple units at the same site (-C1, -C2).

SITE LOCATIONS

SITE #	UTM (E)	UTM (N)	LAT	LONG	ELEV (m)
A1	618000	5095000	460000	672836	70
A1a	618000	5094975	455959	672836	65
A2	618000	5093000	455853	672835	190
A3	618000	5091000	455750	672835	145
A4	617350	5089650	455708	672910	155
A5	618000	5087000	455538	672838	150
A6	618000	5085000	455435	672832	160
A7	618000	5083000	455330	672840	200
A8	618000	5081000	455230	672850	180
A9	618000	5079000	455122	672845	165
A10	618000	5077000	455020	672848	275
A11	618000	5075000	454915	672850	210
A12	618000	5072700	454759	672852	210
A13	617850	5071050	454705	672900	210
A14	618000	5069000	454558	672858	200
B1	620000	5095000	460000	672702	50
B2	620000	5093000	455851	672706	120
B3	620000	5091000	455750	672708	210
B4	620025	5089075	455647	672703	140
B5	620000	5087000	455540	672710	160
B6	620025	5085025	455438	672700	185
B7	620000	5083000	455330	672713	220
B8	620000	5081000	455227	672712	175
B9	619900	5079000	455125	672718	175
B10	620000	5077000	455018	672718	240
B11	620000	5075000	454912	672718	222
B12	619900	5073100	454812	672725	260
B13	619950	5071100	454705	672725	285

SITE #	UTM (E)	UTM (N)	LAT	LONG	ELEV (m)
B14	620000	5068950	454557	672725	270
C1	622000	5095000	455959	672528	160
C1.5	622600	5093550	452502	675912	50
C2	621750	5092680	455845	672535	75
C3	622000	5091000	455748	672530	170
C4	622000	5089000	455642	672533	140
C5	622000	5087000	455537	672537	190
C6	622000	5085000	455432	672537	230
C7	622000	5083000	455330	672540	250
C8	622000	5081000	455225	672540	220
C9	622000	5079000	455118	672542	170
C10	621850	5077000	455015	672550	175
C11	622000	5075000	454910	672545	170
C12	622000	5073000	454805	672547	180
C13	622000	5071000	454701	672549	260
C14	622000	5069000	454556	672553	255
D1	624150	5094900	455957	672352	180
D2	624000	5093000	455850	672400	100
D3	624150	5090750	455740	672350	130
D4	624000	5089000	455642	672400	190
D5	624000	5087000	455537	672402	195
D6	624000	5085000	455432	672405	215
D7	624000	5083000	455329	672407	170
D8	624200	5081000	455224	672400	200
D9	624000	5079000	455118	672410	160
D10	624025	5077000	455015	672407	120
D11	624150	5075000	454908	672403	195
D12	624000	5073000	454805	672412	190
D13	624000	5071000	454700	672418	180
D14	624000	5069000	454555	672417	180

SITE #	UTM (E)	UTM (N)	LAT	LONG	ELEV (m)
E1	626000	5094900	455950	672225	245
E2	626000	5093000	455812	672225	100
E2H	626000	5093006	455812	672225	101
E3	625980	5090700	455735	672230	10
E4	626000	5089000	455640	672230	185
E5	625800	5087150	455540	672238	135
E6	626200	5085025	455430	672222	130
E7	626000	5083000	455325	672230	150
E8	626000	5081000	455220	672248	150
E9	626550	5079350	455127	672220	165
E10	626000	5077000	455014	672235	155
E11	626000	5075000	454905	672238	165
E12	626250	5072850	454800	672230	160
E13	625900	5071000	454700	672247	160
E14	626000	5069000	454555	672247	175
F1	628000	5095000	455952	672050	150
F2	628000	5093000	455850	672053	100
F3	628000	5091250	455752	672055	55
F4	628000	5089000	455643	672058	190
F5	628400	5087200	455538	672038	150
F6	628000	5085000	455430	672100	130
F7	628200	5083100	455330	672055	130
F8	628000	5081000	455222	672100	150
F9	628000	5079000	455122	672103	160
F10	628150	5077000	455010	672100	150
F11	628500	5075100	454910	672048	145
F12	627900	5073100	454803	672115	140
F13	628200	5071000	454553	672117	140
F14	627950	5068950	454655	672100	150
G1	630000	5095000	455952	671920	140

SITE #	UTM (E)	UTM (N)	LAT	LONG	ELEV (m)
G2	630000	5093000	455845	671915	135
G2.5	629150	5091925	455812	671957	65
G3	630125	5091100	455750	671912	55
G4	630000	5089000	455640	671925	95
G5	630000	5087000	455530	671922	165
G6	630000	5085000	455430	671925	175
G7	629800	5082950	455323	671935	140
G8	630000	5081000	455215	671935	140
G9	630500	5079250	455122	671930	134
G10	630250	5077250	455017	671923	134
G11	630000	5075000	454905	671935	160
G12	629900	5072900	454800	671942	180
G13	630000	5071000	454657	671940	190
G14	630000	5069050	454551	671940	185
H1	632000	5095000	455950	671745	120
H2	632000	5093000	455840	671742	110
H2A	632000	5092950	455840	671742	105
H3	632000	5091000	455743	671750	65
H4	632000	5089000	455642	671748	140
H5	632000	5087000	455530	671750	170
H6	632000	5085000	455425	671750	165
H7	632000	5083000	455327	671752	150
H8	632000	5081000	455220	671755	220
H9	632000	5079000	455113	671759	160
H10	632000	5077000	455010	671800	155
H11	632150	5075200	454908	671752	165
H12	632000	5073000	454800	671803	205
H13	632000	5071000	454652	671805	260
H14	632000	5069000	454551	671808	180
K1	634000	5095000	455955	671610	165
K2	634000	5093000	455850	671615	150

SITE #	UTM (E)	UTM (N)	LAT	LONG	ELEV (m)
K3	634000	5091000	455742	671615	70
K4	634000	5089000	455635	671618	240
K5AL	634000	5087000	455530	671820	175
K5SOL	634000	5087000	455530	671820	175
K6	634005	5085000	455435	671610	150
K7	633990	5083005	455322	671620	195
K8	634000	5081000	455202	671620	220
K9	634000	5079000	455118	671630	215
K10	633800	5077050	455008	671632	160
K11	633800	5074900	454907	671635	155
K12	634000	5073000	454803	671633	220
K13	634000	5071000	454655	671633	205
K14	634000	5069000	454550	671638	220
L1A	635701	5095200	455951	671447	82
L1B	635700	5095200	455951	671447	81
L2	636000	5093000	455848	671440	70
L3	636275	5091100	675740	671430	60
L4	636200	5089000	455635	671437	70
L5	636000	5087000	455525	671446	140
L6	636000	5085000	455417	671443	110
L7	636000	5083000	455323	671445	120
L8	636000	5081300	455230	671447	135
L9	635990	5078975	455108	671500	150
L10	636000	5077000	455006	671458	140
L11	636000	5075000	454900	671500	165
L12	635600	5072800	454755	671515	220
L13	636000	5071000	454650	671500	190
L14	635950	5069000	454549	671508	290
M1	638150	5095250	455955	671200	60

SITE #	UTM (E)	UTM (N)	LAT	LONG	ELEV (m)
M2	638000	5093000	455840	671305	140
M3	638000	5091000	455737	671305	165
M4	638000	5089000	455632	671313	130
M5	638000	5087000	455535	671310	120
M6	637650	5084950	455420	671332	110
M7	637600	5082550	455259	671330	120
M8	637900	5080850	455155	671220	180
M9	638000	5079000	455100	671215	165
M10	638000	5076900	455000	671323	130
M11	638050	5075000	454900	671320	120
M12	638000	5073000	454755	671330	145
M13	638000	5071000	454643	671330	145
M14	638000	5069000	454543	671332	155
N1	640000	5095000	455945	671130	150
N2	639950	5092375	455815	671140	50
N3	640000	5091000	455730	671135	140
N4	640000	5089000	455632	671140	170
N5	640000	5087000	455533	671135	130
N6	639100	5084800	455418	671225	120
N7	640000	5083000	455325	671140	155
N8	640300	5080800	455205	671140	140
N9	640050	5079025	455102	671145	140
N10	640650	5076300	454940	671123	130
N11	640000	5075000	454857	671155	140
N12	640000	5073000	454752	671157	125
N13	640300	5071000	454646	671158	122
N14	640250	5069000	454548	671152	110
P1	641500	5094850	455935	671025	140
P2	642175	5093350	455845	670950	100

SITE #	UTM (E)	UTM (N)	LAT	LONG	ELEV (m)
P3	642000	5091000	455735	671000	200
P4	641550	5089300	455637	671027	160
P5	642000	5087000	455527	671005	150
P7	642000	5083000	455318	671005	140
P8	642000	5081000	455218	671005	135
P9	642000	5079000	455105	671018	138
P10	641990	5076990	454955	671022	135
P11	641950	5075025	454900	671023	130
P12	642500	5072700	454740	670957	140
P13	642100	5071100	454650	671020	163
P14	642000	5069000	454543	671030	230
Q1	644000	5095000	455940	670825	205
Q2	644000	5093000	455835	670830	75
Q3	644000	5091000	455732	670827	60
Q4	644000	5089000	455620	670825	155
Q5	644000	5087000	455518	670835	190
Q6	643550	5085200	455427	670900	130
Q7	643650	5083150	455325	670805	140
Q9	644200	5078600	455050	670835	130
Q10	644350	5076850	454951	670834	160
Q11	644000	5075000	454853	670847	145
Q12	644000	5073000	454747	670848	170
Q13	644000	5071000	454647	670853	150
Q14	644000	5069000	454543	670855	145
R1	646000	5095000	455940	670652	145
R2	646000	5093000	455840	670656	141
R3	646550	5091100	455735	670638	110
R4	646175	5089000	455625	670657	78
R5	646000	5087000	455520	670700	160

SITE #	UTM (E)	UTM (N)	LAT	LONG	ELEV (m)
R6	646400	5084975	455419	670646	145
R7	646550	5082200	455252	670637	130
R9	646000	5079000	455105	670713	150
R10	646000	5077000	454955	670722	220
R11	645975	5075050	454858	670720	165
R12	646750	5072800	454742	670640	150
R13	645200	5071750	454713	670759	150
R14	645000	5068350	454523	670810	150
S2	647400	5092500	455838	670555	153
S3	648000	5091000	455729	670530	175
S4	648350	5089550	455647	670515	100
S5	648000	5087000	455517	670520	120
S6	648000	5085000	455420	670530	195
S7	647650	5082750	455303	670550	205
S8	648200	5081000	455205	670523	152
S9	647800	5078800	455057	670600	130
S9-2	647500	5078800	455053	670605	140
S10	648000	5077000	454957	670541	140
S11	647900	5075000	454856	670550	140
S12	647650	5073000	454740	670555	140
S13	647700	5071475	454657	670600	150
S14	649250	5068600	454527	670457	150
T2	650000	5093000	455835	670347	145
T3	650000	5091000	455730	670350	203
T4	650000	5089000	455626	670356	180
T5	649500	5086500	455500	670312	75
T6	650000	5085000	455415	670357	215
T7	649900	5083100	455315	670410	175
T8	650500	5081000	455208	670335	145

SITE #	UTM (E)	UTM (N)	LAT	LONG	ELEV (m)
T9	650000	5079000	455104	670403	160
T10	649750	5076700	454945	670430	135
T11A	650000	5075000	454855	670408	140
T11B	650200	5075150	454852	670405	130
T12	650450	5072950	454740	670352	140
T13	649950	5071100	454647	670420	150
T14	650600	5069500	454553	670350	150
V1	652000	5095000	455938	670220	135
V2	652000	5093000	455837	670218	130
V3	652000	5091000	455728	670225	223
V4	651650	5089200	455630	670335	160
V5	652925	5087800	455540	670147	80
V6	652000	5085000	455417	670222	105
V7	651250	5083000	455312	670300	153
V7.5	651200	5082000	455237	670307	150
V8	652000	5081000	455205	670230	140
V9	652000	5079000	455059	670238	184
V10	652350	5077000	454952	670236	145
V12	652000	5073000	454748	670247	145
V13	652000	5071350	454650	670244	155
V14	651850	5069150	454540	670247	146
W1	654000	5095000	455940	670045	120
W2	654000	5093000	455835	670048	125
W3	654000	5091000	455727	670052	160
W4	654000	5089000	455627	670057	122
W5	654000	5087000	455520	670058	110
W6	653900	5084850	455347	670052	60
W7	654000	5083000	455317	670102	97
W8	654000	5081000	455202	670103	120

SITE #	UTM (E)	UTM (N)	LAT	LONG	ELEV (m)
W9	654000	5079000	455059	670103	140
W10	654000	5077000	454952	670104	155
W11	653300	5075200	454855	670132	136
W12	654000	5073000	454744	670115	148
W13	653350	5071050	454647	670116	147
W14	653700	5068800	454530	670117	148

APPENDIX II

PEBBLE AND MATRIX LITHOLOGY

Pebble Lithology

Lithological studies were performed on clasts obtained from 247 sites. Clasts were sampled from the C-horizon. In most cases this unit was considered, sensu stricto, to be basal till (Dreimanis, 1976). Between 50 to 100 clasts were recovered at each site, in the 3 to 8 centimetre size range.

Clasts were divided into 10 identifiable groups: granites, felsic dykes (aplite, red-pink porphyries), mafic dykes (diabase, gabbro), volcanics, eastern sedimentary rocks (turbidites), western sedimentary rocks, purple slates, Carboniferous conglomerates, vein quartz, and Dow Porphyry. Data were plotted and contoured using a program called SURFER®. Possible sources were indicated by the contoured dispersal pattern.

Headings used in the data tables (Parts A and B) refer to the following lithologies: GRAN% (granite); DYKF% (felsic porphyries); APL% (aplite); DYKM% (mafic intrusives); VOLC% (volcanics); DP% (Dow Porphyry); QTZ% (vein quartz); SEDW% (western sedimentary rocks); SEDE% (eastern sedimentary rocks); PSED% (purple slates); and, CARB% (Carboniferous conglomerates).

Matrix Lithology

The silt - sand fraction from the granulometric analysis was visually analyzed to determine matrix lithology (MX in Part B). Lithology was determined by colour and the resemblance of clast lithologies to bedrock groups. Samples were rated according to granite content. The rating scheme ranged from one (dominantly granite) to five (little or no granite).

The rating values of the samples were plotted using SURFER®, to compare the areal distribution of matrix lithology with the underlying bedrock.

LITHOLOGY DATA - PART A

SITE#	GRAN%	DYKF%	APL%	DYKM%	VOLC%	DP%
A1						
A1a	0	0	0	31	2	0
A2	0	0	0	3	11	0
A3	0	0	0	14	37	0
A4	3	0	0	13	28	0
A5	0	0	0	35	30	1
A6	0	0	0	12	20	0
A7	0	0	0	0	96	3
A8	0	0	0	25	69	2
A9	2	0	0	7	24	0
A10	0	0	0	0	68	2
A11	17	0	0	18	8	0
A12	52	0	0	4	16	0
A13	42	0	0	10	18	0
A14	27	0	0	8	8	0
B1	3	0	0	10	23	0
B2	1	0	0	14	1	0
B3	3	1	0	9	29	1
B4	0	0	0	0	87	0
B5	0	4	0	20	25	0
B6	0	0	0	19	14	0
B7	0	0	0	1	98	0
B8	0	0	2	6	76	2
B9	0	0	0	3	43	0
B10	2	0	0	4	14	0
B11	3	4	4	14	15	3
B12	5	1	1	1	16	0
B13	14	0	0	3	17	0
B14	31	0	0	1	11	0
C1	0	0	0	0	20	0
C1.5	2	0	0	14	32	0
C2	3	0	0	1	13	0
C3	2	0	0	0	4	0
C4	0	0	0	0	100	0
C5	0	0	0	8	84	0

SITE#	GRAN%	DYKF%	APL%	DYKM%	VOLC%	DP%
C6	0	0	0	60	20	2
C7	0	14	0	18	14	0
C8	5	1	1	8	37	0
C9	0	2	0	12	38	0
C10	12	0	0	0	6	0
C11	14	0	2	10	46	0
C12	1	0	1	3	24	0
C13	10	0	6	8	16	0
C14	32	0	0	0	18	2
D1	10	0	0	21	17	0
D2	0	0	0	0	10	0
D3	3	0	0	2	1	0
D4	3	1	0	12	13	0
D5	0	0	0	12	30	0
D6	0	0	0	14	57	0
D7	16	0	0	12	20	2
D8	40	0	0	1	21	4
D9	1	0	0	9	34	0
D10	10	0	6	4	28	0
D11	50	5	10	3	12	0
D12	15	0	0	3	45	0
D13	62	0	0	4	12	0
D14	44	0	0	4	6	0
E1	4	0	0	16	30	0
E2	0	0	0	20	25	0
E2H	0	0	0	10	40	0
E3	0	0	0	2	16	0
E4	3	0	0	7	5	0
E5	0	3	0	12	18	0
E6	4	0	0	18	34	0
E7	10	2	6	12	34	0
E8	40	0	0	11	13	0
E9	66	0	0	2	2	0
E10	40	0	0	12	18	0
E11	4	0	0	40	16	0
E12	55	0	0	3	5	1

SITE#	GRAN%	DYKF%	APL%	DYKM%	VOLC%	DP%
E13	33	0	10	4	13	1
E14	35	0	3	3	14	0
F1	0	0	0	20	34	0
F2	0	0	0	18	44	0
F3	2	0	0	16	40	0
F4	7	0	0	12	4	0
F5	0	0	0	21	25	0
F6	8	4	1	9	26	0
F7	5	0	0	13	5	1
F8	14	0	0	10	16	4
F9	66	0	0	2	19	0
F10	58	0	0	12	16	0
F11	57	0	4	3	8	0
F12	66	0	0	0	8	0
F13	5	0	2	2	26	0
F14	14	0	6	4	12	0
G1	4	0	0	20	14	0
G2	20	0	0	20	30	0
G2.5	7	0	0	4	25	0
G3						
G4	6	0	0	12	62	0
G5	4	0	2	11	11	0
G6	0	0	2	0	4	0
G7	17	0	0	14	26	0
G8	48	0	0	12	14	0
G9	52	0	0	9	11	0
G10	62	0	2	9	10	0
G11	61	0	1	4	7	0
G12	50	0	2	0	10	0
G13	16	0	8	2	30	2
G14	68	0	3	4	2	0
H1	13	0	0	11	31	1
H2	60	0	4	4	24	0
H2A	56	0	3	3	20	0
H3	4	0	0	12	34	0
H4	2	0	0	0	6	0

SITE#	GRAN%	DYKF%	APL%	DYKM%	VOLC%	DP%
H5	13	0	0	22	20	0
H6	9	0	1	16	35	0
H7	4	0	4	16	14	0
H8	6	0	1	7	14	0
H9	54	0	0	4	11	0
H10	65	0	0	7	6	0
H11	32	0	0	14	14	0
H12	34	0	0	12	10	0
H13	23	0	1	15	17	0
H14	69	0	1	1	8	0
K1	2	0	2	10	18	0
K2	0	0	0	10	6	0
K3	20	0	2	4	14	0
K4	12	0	0	10	20	0
K5AL	12	0	0	17	10	0
K5SOL	12	0	0	16	12	0
K6	4	0	0	10	6	0
K7	10	0	0	8	2	0
K8	8	0	0	5	5	0
K9	8	0	0	6	2	0
K10	8	0	1	18	15	0
K11	51	0	4	6	1	0
K12	12	0	0	7	4	0
K13	47	0	11	15	9	0
K14	36	0	0	6	8	1
L1A	3	0	0	11	4	0
L1B	0	0	1	8	7	0
L2	17	0	1	5	4	0
L3	94	0	0	0	2	0
L4	16	0	0	6	6	0
L5						
L6	80	0	0	0	0	0
L7	64	0	0	4	0	0
L8	68	0	0	6	2	0
L9	32	2	4	8	4	0
L10	16	0	0	4	2	0

SITE#	GRAN%	DYKF%	APL%	DYKM%	VOLC%	DP%
L11	14	0	0	6	8	0
L12	42	0	4	6	6	0
L13	12	0	4	10	4	0
L14	18	0	0	8	10	0
M1	8	0	4	12	0	0
M2	2	0	2	22	4	0
M3	10	0	0	6	2	0
M4	42	0	0	3	1	0
M5	29	1	0	4	2	0
M6	8	0	0	12	2	0
M7						
M8	6	0	2	8	0	0
M9	16	0	0	8	6	0
M10	88	0	0	2	2	0
M11	62	0	0	10	2	0
M12	74	0	0	6	0	0
M13	8	0	0	6	0	0
M14	20	2	3	11	12	0
N1						
N2						
N3	0	0	0	0	2	0
N4	20	22	0	0	0	0
N5	73	0	0	2	1	0
N6	34	0	0	4	4	0
N7	52	0	4	4	2	0
N8	6	0	0	0	8	0
N9	34	0	2	8	0	0
N10	74	0	0	0	0	0
N11	20	0	0	8	6	0
N12	58	0	0	2	0	0
N13						
N14						
P1	0	0	1	9	2	0
P2	2	0	1	4	1	0
P3	21	0	0	6	4	0
P4	48	0	0	10	0	0

SITE#	GRAN%	DYKF%	APL%	DYKM%	VOLC%	DP%
P5	20	0	0	6	8	0
P7	50	0	6	4	0	0
P8	22	0	0	4	10	0
P9	10	0	5	4	7	0
P10	6	0	0	10	6	0
P11	16	0	4	2	10	0
P12	22	0	0	6	2	0
P13	90	0	0	2	0	0
P14	8	0	4	10	2	0
Q1	25	0	0	10	0	0
Q2	31	0	0	8	3	0
Q3						
Q4	10	0	7	5	4	0
Q5	0	0	6	6	6	0
Q6	24	4	4	6	16	0
Q7	24	0	16	10	4	0
Q9	52	0	2	6	10	0
Q10	54	4	10	0	2	0
Q11	52	0	8	0	2	0
Q12	19	0	1	1	4	0
Q13	18	0	0	8	4	0
Q14	24	0	2	0	2	0
R1	7	0	4	18	15	0
R2	3	0	2	6	11	0
R3	3	0	1	8	10	0
R4						
R5	2	0	2	8	6	0
R6	4	0	6	10	8	0
R7	10	0	0	8	2	0
R9	4	0	0	6	8	0
R10	3	0	1	2	6	0
R11	20	0	4	4	2	0
R12	2	0	0	6	2	0
R13	16	0	2	6	2	0
R14	20	0	6	0	0	0
S2	11	0	0	5	26	1

SITE#	GRAN%	DYKF%	APL%	DYKM%	VOLC%	DP%
S3	3	1	0	24	9	0
S4						
S5	0	0	4	8	2	0
S6	2	4	0	18	8	0
S7	2	0	0	14	4	0
S8	6	0	2	12	8	0
S9-2	14	0	0	10	8	0
S10						
S11	0	0	2	4	2	0
S12	3	0	1	1	1	0
S13	0	0	0	0	2	0
S14	0	0	0	0	0	0
T2	4	0	6	8	0	0
T3	3	0	0	11	4	0
T4						
T5						
T6	4	0	0	23	6	1
T7	4	4	0	18	4	4
T8	4	2	2	24	6	4
T9						
T10	3	0	2	14	10	0
T11B	4	2	0	10	0	1
T12	8	0	0	6	8	0
T13	8	0	0	2	2	0
T14	0	0	4	2	0	0
V1	5	0	0	14	7	0
V2	48	0	0	2	0	0
V3						
V4	10	0	6	12	10	0
V5	4	0	4	5	2	0
V6						
V7	2	0	8	4	12	0
V7.5	0	4	4	14	10	0
V8	0	0	5	6	10	0
V9	2	0	0	0	0	0
V10	6	0	0	6	2	0

SITE#	GRAN%	DYKF%	APL%	DYKM%	VOLC%	DP%
V12	12	0	4	4	0	0
V14	1	0	3	9	5	0
W1	14	0	0	2	6	0
W2	10	0	2	3	4	0
W3						
W4	4	0	2	10	4	0
W5	3	0	2	2	3	0
W6	0	0	0	0	0	0
W7						
W8	6	0	0	2	3	0
W9						
W10	2	0	1	3	7	0
W11	6	0	4	10	16	0
W12	2	0	0	12	2	0
W13	0	0	2	10	4	0
W14	5	0	0	9	5	0

LITHOLOGY DATA - PART B

SITE#	QTZ%	SEDW%	SEDE%	PSED%	CARB%	MX
A1						5
A1a	5	62	0	0	0	5
A2	0	86	0	0	0	5
A3	0	49	0	0	0	5
A4	3	51	0	2	0	5
A5	3	31	0	0	0	5
A6	0	66	0	0	0	5
A7	1	9	0	1	0	5
A8	2	2	0	0	0	4
A9	2	59	0	3	0	5
A10	0	30	0	0	0	2
A11	0	56	0	1	0	5
A12	2	26	0	0	0	1
A13	2	28	0	0	0	1
A14	0	57	0	0	0	2
B1	0	64	0	0	0	5
B2	1	86	0	0	0	5
B3	2	56	0	0	0	5
B4	2	11	0	0	0	5
B5	2	49	0	0	0	5
B6	4	63	0	0	0	5
B7	1	0	0	0	0	5
B8	1	12	0	1	0	5
B9	1	51	0	2	0	5
B10	2	74	0	0	0	5
B11	4	57	0	1	0	5
B12	1	72	0	4	0	3
B13	6	60	0	0	0	3
B14	0	56	0	1	0	3
C1	0	80	0	0	0	5
C1.5	0	44	0	8	0	5
C2	0	83	0	0	0	5
C3	0	94	0	0	0	5
C4	0	0	0	0	0	5
C5	0	8	0	0	0	5

SITE#	QTZ%	SEDW%	SEDE%	PSED%	CARB%	MX
C6	4	14	0	0	0	4
C7	2	52	0	0	0	4
C8	2	45	0	1	0	3
C9	4	44	0	0	0	5
C10	0	82	0	0	0	3
C11	0	26	0	2	0	2
C12	2	67	0	2	0	4
C13	4	54	0	2	0	3
C14	0	48	0	0	0	4
D1	1	51	0	0	0	3
D2	4	86	0	0	0	5
D3	0	94	0	0	0	5
D4	3	64	0	3	0	5
D5	0	58	0	0	0	4
D6	0	29	0	0	0	3
D7	0	54	0	0	0	2
D8	2	33	0	1	0	2
D9	2	54	0	0	0	5
D10	0	52	0	0	0	2
D11	3	15	0	2	0	1
D12	0	37	0	0	0	2
D13	4	18	0	0	0	1
D14	2	44	0	0	0	1
E1	0	50	0	0	0	1
E2	0	54	0	1	0	1
E2H	4	46	0	0	0	4
E3	0	82	0	0	0	4
E4	0	84	0	1	0	3
E5	2	64	0	0	0	5
E6	2	40	0	2	0	2
E7	0	36	0	0	0	2
E8	1	35	0	0	0	2
E9	0	30	0	0	0	2
E10	2	26	0	2	0	3
E11	0	38	0	2	0	3
E12	1	35	0	0	0	2

SITE#	QTZ%	SEDW%	SEDE%	PSED%	CARB%	MX
E13	0	39	0	0	0	1
E14	3	42	0	1	0	1
F1	0	46	0	0	0	3
F2	0	37	0	1	0	4
F3	0	41	0	1	0	4
F4	0	75	0	2	0	4
F5	3	50	0	1	0	3
F6	1	51	0	0	0	2
F7	1	74	0	1	0	2
F8	2	54	0	0	0	2
F9	0	13	0	0	0	1
F10	0	14	0	0	0	1
F11	0	28	0	0	0	1
F12	2	24	0	0	0	1
F13	0	65	0	0	0	2
F14	0	60	0	4	0	1
G1	6	54	0	2	0	5
G2	0	30	0	0	0	2
G2.5	2	62	0	0	0	4
G3						3
G4	0	20	0	0	0	3
G5	5	67	0	0	0	3
G6	0	94	0	0	0	4
G7	1	42	0	0	0	3
G8	0	26	0	0	0	2
G9	0	28	0	0	0	1
G10	1	16	0	0	0	1
G11	1	25	0	1	0	1
G12	2	36	0	0	0	1
G13	0	48	0	2	0	1
G14	0	23	0	0	0	1
H1	3	41	0	0	0	4
H2	0	8	0	0	0	1
H2A	0	18	0	0	0	
H3	4	50	0	2	0	4
H4	2	90	0	0	0	3

SITE#	QTZ%	SEDW%	SEDE%	PSED%	CARB%	MX
H5	2	41	0	0	0	3
H6	3	36	0	0	0	2
H7	0	60	0	2	0	2
H8	1	71	0	0	0	3
H9	2	29	0	0	0	1
H10	0	22	0	0	0	1
H11	0	40	0	0	0	1
H12	2	42	0	0	0	1
H13	4	40	0	0	0	1
H14	0	21	0	0	0	1
K1	0	68	0	0	0	5
K2	0	86	0	0	0	4
K3	0	60	0	0	0	4
K4	0	58	0	0	0	4
K5AL	0	61	0	0	0	3
K5SOL	10	46	0	4	0	3
K6	0	80	0	0	0	3
K7	0	80	0	0	0	4
K8	0	82	0	0	0	4
K9	0	80	0	4	0	1
K10	1	57	0	0	0	4
K11	0	35	0	2	0	2
K12	0	77	0	0	0	2
K13	0	28	0	0	0	2
K14	0	47	0	2	0	2
L1A	0	80	0	1	0	5
L1B	2	82	0	0	0	5
L2	1	72	0	0	0	3
L3	0	4	0	0	0	1
L4	0	72	0	0	0	4
L5						3
L6	0	20	0	0	0	1
L7	0	32	0	0	0	2
L8	0	24	0	0	0	3
L9	2	46	0	2	0	1
L10	0	78	0	0	0	2

SITE#	QTZ%	SEDW%	SEDE%	PSED%	CARB%	MX
L11	2	70	0	0	0	3
L12	0	42	0	0	0	1
L13	2	62	0	2	0	3
L14	0	64	0	0	0	3
M1	0	76	0	0	0	3
M2	0	70	0	0	0	4
M3	0	82	0	0	0	2
M4	1	53	0	0	0	2
M5	1	57	0	6	0	2
M6	2	76	0	0	0	3
M7						5
M8	0	84	0	0	0	3
M9	6	64	0	0	0	2
M10	0	8	0	0	0	1
M11	0	24	0	0	0	1
M12	4	16	0	0	0	3
M13	0	86	0	0	0	3
M14	1	51	0	0	0	1
N1						3
N2						4
N3	0	96	0	2	0	5
N4	0	56	0	2	0	1
N5	0	24	0	0	0	2
N6	2	56	0	0	0	3
N7	2	32	0	2	0	1
N8	0	84	0	2	0	5
N9	0	56	0	0	0	3
N10	0	26	0	0	0	1
N11	4	62	0	0	0	3
N12	4	36	0	0	0	2
N13						4
N14						3
P1	0	88	0	0	0	5
P2	0	92	0	0	0	5
P3	0	69	0	0	0	4
P4	0	42	0	0	0	2

SITE#	QTZ%	SEDW%	SEDE%	PSED%	CARB%	MX
P5	0	66	0	0	0	2
P7	0	40	0	0	0	1
P8	0	64	0	0	0	2
P9	0	74	0	0	0	4
P10	0	78	0	0	0	5
P11	0	66	0	2	0	5
P12	0	68	0	4	0	2
P13	0	8	0	0	0	1
P14	0	0	76	0	0	4
Q1	0	60	0	0	0	4
Q2	0	44	0	0	0	2
Q3						5
Q4	0	74	0	0	0	3
Q5	0	82	0	0	0	3
Q6	2	46	0	0	0	1
Q7	0	46	0	0	0	1
Q9	0	30	0	0	0	2
Q10	0	30	0	0	0	1
Q11	0	0	38	0	0	1
Q12	0	0	75	0	0	2
Q13	0	0	70	0	0	3
Q14	0	0	52	0	0	4
R1	0	55	0	1	0	3
R2	0	77	0	1	0	3
R3	0	78	0	0	0	3
R4						4
R5	0	82	0	0	0	3
R6	0	72	0	0	0	4
R7	0	80	0	0	0	3
R9	0	82	0	0	0	3
R10	1	86	0	0	0	3
R11	6	0	64	0	0	2
R12	0	0	88	2	0	3
R13	8	0	66	0	0	3
R14	4	0	70	0	0	2
S2	0	52	0	0	1	3

SITE#	QTZ%	SEDW%	SEDE%	PSED%	CARB%	MX
S3	0	61	0	1	1	3
S4						3
S5	2	84	0	0	0	3
S6	0	64	0	0	4	3
S7	0	74	0	2	4	4
S8	2	68	0	2	0	4
S9-2	2	0	66	0	0	3
S10						3
S11	0	0	90	0	2	3
S12	0	0	94	0	0	4
S13	0	0	98	0	0	4
S14	0	0	100	0	0	5
T2	4	78	0	0	0	1
T3	1	81	0	0	0	4
T4						2
T5						3
T6	2	0	63	1	0	3
T7	0	0	64	2	0	3
T8	2	0	56	0	0	3
T9						3
T10	0	0	67	3	1	3
T11B	0	0	84	0	0	3
T12	2	0	78	0	0	3
T13	0	0	88	0	0	2
T14	2	0	92	0	0	4
V1	1	73	0	0	0	4
V2	0	49	0	1	0	3
V3						2
V4	0	62	0	0	0	2
V5	0	70	0	0	0	2
V6						2
V7	0	0	74	0	0	4
V7.5	0	0	68	0	0	3
V8	0	0	79	0	0	1
V9	0	0	98	0	0	2
V10	2	0	84	0	0	3

SITE#	QTZ%	SEDW%	SEDE%	PSED%	CARB%	MX
V12	0	0	80	0	0	2
V14	3	0	77	2	0	2
W1	2	76	0	0	0	3
W2	1	80	0	0	0	4
W3						2
W4	2	0	76	2	0	1
W5	2	0	88	0	0	2
W6	1	0	98	0	1	3
W7						4
W8	1	0	85	0	3	3
W9						3
W10	3	0	82	0	2	3
W11	2	0	62	0	0	3
W12	0	0	84	0	0	4
W13	2	0	82	0	0	4
W14	1	0	72	0	7	3

APPENDIX III

GRANULOMETRIC ANALYSES

A total of 273 C-horizon samples were analyzed using the ASTM (1964) hydrometer/sieving technique with minor modifications (specifically: dispersing agent and reading times). Calgon® was used as the dispersing agent instead of sodium hexametaphosphate. Initial testing of the two dispersing agents produced no difference in results.

The time at which readings were taken was also modified. Studies by Broster (1982), suggested that readings taken earlier than the 15 minute mark (sand fraction) were unreliable and difficult to reproduce in subsequent tests. Broster (ibid.) also recommended that a hydrometer reading be taken at the 12 hour mark to more clearly define the silt-clay boundary. In the present study, samples were run in sets of eight, with the first reading taken at the 15 minute mark and the last at 24 hours, according to the ASTM (1964) manual. An additional hydrometer reading was taken at the 12 hour mark.

The data were plotted as cumulative curves on arithmetic ordinate paper using grain diameters in phi units and millimetres. From this curve, statistical parameters for grain size can be determined, including: sand/silt/clay percentages; graphic mean (M_z); inclusive graphic standard deviation (σ_I); inclusive graphic skewness (Sk_I); and graphic kurtosis (K_G) (cf. Folk, 1974).

Sand/Silt/Clay Ratio

Sand, silt and clay percentages are read directly from the curve using the phi divisions -1.0 to 4.0, 4.0 to 9.0, and, +9.0, respectively. These percentages represent the components of the matrix and do not take into consideration any portion of the sample that is larger than the -1.0 phi size fraction (e.g. pebbles and cobbles).

Statistical Parameters

To determine correlations between samples, it is easier to compare statistical parameters quantitatively rather than visually. Statistical parameters were determined using formulae supplied by Folk (1974).

Graphic Mean

Graphic mean is the best graphic measure for determining overall size of a sample. It is given by the formula:

$$M_z = (\phi 16 + \phi 50 + \phi 84)/3$$

This value, based on three points of the curve, gives a better overall representation of the average grain size of the sample (Folk, 1974).

Inclusive Graphic Standard Deviation

The inclusive graphic standard deviation includes 90 % of the curve in its measure and is therefore the best estimate of grain sorting for the samples (Folk, 1974). It is given by

the formula:

$$\sigma_I = (\phi 84-\phi 16)/4 + (\phi 95-\phi 5)/6.6$$

According to Folk (1974) sorting values theoretically range from 0.00 phi to infinity, where the lower the value, the better the sorting. In glacial areas, most sediments tend to be poorly sorted, with values normally 4.0 phi or greater (Folk, ibid.).

Inclusive Graphic Skewness

Often, curves display similar characteristics in terms of average grain size and sorting, but differ in the proportion of finer versus coarser material. The difference in the amount of fine versus coarse grains is determined by measuring the asymmetry of the curves with respect to normal distribution.

Inclusive graphic skewness measures 90 % of the curve, including most of the tail section. It is given by the formula (Folk, 1974):

$$Sk_I = ((\phi 16+\phi 84 - 2\phi 50)/2(\phi 84-\phi 6))+((\phi 5+\phi 95 - 2\phi 50)/2(\phi 95-\phi 5))$$

Skewness values range from -1.00 to +1.00, where perfectly symmetrical curves have a skewness of 0.00. Curves with excess fine material are positively skewed, while those with excess coarse material are negatively skewed.

Graphic Kurtosis

A normal probability curve should produce a straight line. This line will have a normal kurtosis, or peakedness, of (K_G = 1.00). Graphic kurtosis measures the ratio between sorting in the tails of the curve and in the central portion (Folk, 1974). It is given by the formula

$$K_G = (\phi 95-\phi 5)/(2.44(\phi 75-\phi 25))$$

Kurtosis values range from 0.41 to infinity, although most sediments fall in the range of 0.60 to 5.00 (Folk, 1974). If the central portion is better sorted than the tails, the curve is leptokurtic (K_G= +1.50). If the tails are better sorted, the curve is platykurtic (K_G= 0.41 to 1.11). Curves that are neither platy- or leptokurtic are termed mesokurtic. Strongly platykurtic curves are often bimodal.

The significance of kurtosis values to studies of glacial sediments is not well understood. These values, along with other parameters, were used to determine possible correlations between samples and their depositional environment.

GRANULOMETRIC DATA

Sample #	Sand%	Silt%	Clay%	Mz	IGSD	Sk1	KG
A1	56	38	6	4.21	-1.78	-0.52	1.72
A1a	76	22	2	2.02	-2.64	-0.45	0.89
A2	42	46	13	4.71	-3.64	0.05	0.93
A3	38	47	15	4.79	-3.85	0.03	0.87
A4	45	44	11	4.34	-3.74	0.05	0.86
A5	39	50	11	4.68	-3.53	0.09	0.89
A6	32	55	13	5.27	-3.82	-0.07	1.28
A7	40	53	8	4.51	-3.00	0.03	1.19
A8	62	35	4	3.02	-2.77	-0.06	0.89
A9	59	39	2	2.99	-2.58	0.01	0.72
A10	39	56	5	4.32	-2.62	0.20	1.13
A11	40	47	13	4.71	-3.75	0.00	1.05
A12	50	44	6	3.75	-3.12	0.02	0.90
A13-C1	70	26	4	2.87	-2.88	-0.34	0.94
A13-C2	38	53	10	4.60	-3.47	0.09	1.17
A14	54	38	8	3.38	-3.28	-0.13	0.87
B1	67	29	4	2.15	-3.06	-0.49	0.73
B2	57	34	10	3.42	-3.62	-0.26	0.86
B3	37	53	10	4.61	-3.65	0.12	0.87
B4	35	61	4	4.19	-2.71	0.28	1.21
B5	32	57	11	4.96	-3.36	0.13	1.07
B6	39	56	6	4.37	-3.04	0.26	0.92
B7	46	51	3	4.02	-2.53	0.12	1.07
B8	65	32	3	2.83	-2.81	-0.13	0.83
B9	54	43	3	3.46	-2.66	0.01	0.83
B10	8	45	46	4.31	-3.35	-0.02	0.90
B11	33	61	6	5.40	-3.50	-0.03	1.03
B12	44	43	13	4.76	-3.78	-0.12	0.98
B13	45	44	11	4.56	-3.55	-0.09	0.96
B14	58	34	8	3.01	-3.42	-0.27	0.78

Sample #	Sand%	Silt%	Clay%	Mz	IGSD	Skl	KG
C1	53	37	10	3.81	-3.67	-0.20	0.91
C1.5	13	68	19	6.76	-2.74	-0.24	1.21
C2	35	43	22	5.62	-4.02	0.00	0.82
C3	38	43	20	5.32	-4.11	0.00	0.82
C4	58	40	2	3.49	-2.43	-0.01	1.10
C5	48	48	4	3.85	-3.01	0.07	0.81
C6	32	61	6	4.72	-2.94	0.17	1.22
C7	37	55	8	4.51	-3.35	0.16	1.08
C8	32	55	14	5.09	-3.78	-0.02	1.27
C9	51	47	2	3.38	-2.67	0.18	0.79
C10	44	52	5	4.07	-2.75	0.15	0.95
C11	43	53	4	4.05	-2.85	0.20	0.93
C12	35	49	16	5.22	-3.68	0.03	0.90
C13	36	51	12	4.95	-3.57	0.03	0.94
C14	39	53	8	4.47	-3.11	0.12	1.07
D1	36	44	20	5.45	-5.17	-0.19	0.81
D2	52	37	10	3.86	-3.75	-0.19	0.87
D3	39	42	19	5.05	-4.10	-0.01	0.76
D4	50	38	12	4.10	-4.20	-0.20	1.05
D5	31	54	15	5.38	-3.67	-0.02	1.30
D6	43	53	4	3.81	-2.75	0.30	1.29
D7	68	27	6	2.44	-3.52	-0.53	1.10
D8	54	41	5	3.40	-3.13	-0.09	0.84
D9	80	19	2	1.79	-2.26	-0.56	0.95
D10	56	36	9	3.26	-3.80	-0.25	1.02
D11	74	21	5	2.33	-3.03	-0.48	1.25
D12	50	46	5	3.64	-3.03	0.08	0.83
D13	78	19	4	2.05	-2.70	-0.45	1.09
D14	60	64	4	2.82	-3.24	-0.41	0.68
E1	41	41	18	5.05	-4.14	-0.11	1.19

Sample #	Sand%	Silt%	Clay%	Mz	IGSD	Sk1	KG
E2	48	41	11	4.28	-3.75	-0.11	0.82
E2H	35	55	10	4.47	-3.62	0.13	1.02
E3	20	60	20	6.39	-3.26	-0.09	1.18
E4	40	43	17	5.19	-3.75	0.03	0.78
E5	85	8	7	0.78	-2.38	-0.60	2.46
E6	32	53	15	5.18	-3.82	0.01	1.13
E7	56	38	7	3.41	-3.24	-0.18	0.82
E8	55	39	6	3.43	-3.34	-0.16	0.79
E9	59	39	3	2.82	-2.79	-0.16	0.76
E10	54	40	6	3.69	-3.17	-0.10	0.90
E11	51	47	2	3.46	-2.41	0.16	0.83
E12	57	41	2	3.09	-2.21	0.21	0.74
E13	58	36	6	3.20	-3.20	-0.19	0.85
E14	58	38	5	3.23	-3.02	-0.15	0.84
F1	37	48	14	4.89	-3.72	0.06	0.81
F2	82	17	2	1.73	-2.49	-0.51	1.18
F3	43	43	14	5.14	-3.28	-0.40	1.56
F4	35	50	16	5.16	-3.66	0.02	0.94
F5	34	47	19	5.20	-4.13	-0.01	0.83
F6	39	47	14	4.78	-3.92	0.00	0.98
F7	42	43	15	4.82	-3.87	-0.03	0.81
F8	50	32	18	4.72	-4.69	-0.31	0.99
F9	58	41	1	2.96	-2.79	-0.08	0.74
F10	55	39	7	3.79	-3.30	-0.22	0.89
F11	57	36	7	3.28	-3.37	-0.19	0.87
F12	58	37	5	2.97	-2.82	-0.11	0.86
F13	61	38	1	3.03	-2.36	0.11	0.76
F14-C1	51	46	3	3.55	-2.34	0.18	0.97
F14-C2	48	49	3	4.12	-1.80	0.03	1.21
G1	25	50	25	6.02	-3.89	-0.06	0.96

Sample #	Sand%	Silt%	Clay%	Mz	IGSD	Sk1	KG
G2	44	45	11	4.41	-3.76	0.00	0.87
G2.5	96	2	2	0.46	-1.09	-0.20	1.17
G3	61	34	5	3.90	-1.79	-0.50	1.30
G4	40	53	7	4.25	-3.30	0.09	1.19
G5	37	48	15	5.07	-3.83	0.02	0.90
G6	33	51	16	5.16	-3.78	-0.02	1.00
G7	41	40	19	5.14	-4.52	-0.11	0.90
G8	68	27	5	2.56	-3.11	-0.44	0.83
G9	70	25	5	2.40	-3.07	-0.41	0.83
G10	71	23	6	2.62	-3.29	-0.49	0.94
G11	79	17	4	1.88	-2.74	-0.50	1.07
G12	70	27	3	2.30	-2.83	-0.40	0.81
G13	77	21	2	1.87	-2.66	-0.51	0.92
G14	64	27	8	3.33	-3.62	-0.38	0.79
H1	41	47	12	4.64	-3.64	0.05	0.85
H2	66	27	7	2.55	-3.25	-0.45	0.92
H3	36	55	9	4.73	-3.15	0.05	1.19
H4	29	55	16	5.44	-3.44	0.01	1.12
H5	35	52	13	4.85	-3.74	0.02	1.17
H6	38	53	9	4.53	-3.30	0.19	0.97
H7	30	57	12	5.02	-3.55	0.09	1.21
H8	45	43	12	4.45	-3.57	-0.05	0.97
H9	52	36	12	4.04	-3.80	-0.20	0.79
H10	86	9	5	0.30	-2.17	-0.72	2.98
H11	55	35	10	3.61	-3.62	-0.23	0.91
H12	61	30	9	2.90	-3.44	-0.39	0.86
H13	53	34	13	3.96	-4.05	-0.27	1.01
H14	68	26	6	2.87	-3.29	-0.43	0.87
K1	37	48	16	5.18	-4.02	-0.11	1.17
K2	42	46	12	4.56	-3.57	0.05	0.96

Sample #	Sand%	Silt%	Clay%	Mz	IGSD	Sk1	KG
K3	36	55	10	5.11	-2.93	-0.20	1.24
K4	33	42	24	9.08	-7.76	-0.44	1.31
K5-AL	39	40	21	5.44	-4.29	-0.10	0.85
K5-SOL	47	46	7	3.97	-3.34	0.04	0.86
K6	38	45	18	5.14	-3.99	0.02	0.85
K7	34	51	15	5.13	-3.60	0.07	0.91
K8	51	35	14	4.15	-3.92	-0.20	0.87
K9	38	42	20	5.20	-4.08	0.00	0.77
K10	36	46	18	5.40	-4.00	0.00	0.91
K11	54	35	11	3.83	-3.54	-0.22	0.87
K12	48	39	12	4.26	-4.00	-0.15	0.97
K13	62	31	7	3.54	-3.41	-0.04	0.83
K14	50	37	12	4.19	-3.67	-0.17	0.80
L1A	27	53	20	5.71	-3.68	0.03	0.95
L1B	29	45	26	5.99	-3.64	0.01	0.79
L2	76	16	8	1.92	-3.10	-0.60	1.09
L3	43	47	10	4.38	-3.31	0.03	1.00
L4	71	26	3	2.22	-2.78	-0.47	0.80
L5	92	5	3	1.18	-1.43	-0.47	2.41
L6	87	11	2	1.74	-1.89	-0.17	1.06
L7	41	47	12	4.50	-3.60	0.10	0.78
L8	52	39	9	3.69	-3.59	-0.14	0.85
L9	53	35	11	3.69	-3.55	-0.20	0.91
L10	65	30	6	2.82	-3.13	-0.29	0.84
L11	68	20	12	3.16	-3.98	-0.54	1.12
L12	46	37	18	4.78	-4.28	-0.11	0.77
L13	49	45	6	3.54	-3.14	0.09	0.85
L14	54	43	3	3.85	-3.81	-0.28	1.02
M1	48	45	7	4.31	-2.44	-0.23	1.41
M2	33	46	21	5.51	-3.88	-0.03	0.86

Sample #	Sand%	Silt%	Clay%	Mz	IGSD	Skl	KG
M3	76	19	5	2.10	-2.94	-0.46	1.05
M3B	44	50	7	3.81	-3.07	0.16	0.93
M4	73	26	2	2.15	-2.68	-0.42	0.79
M5	38	50	12	4.64	-3.63	0.09	0.84
M6	71	22	7	2.37	-3.34	-0.47	1.09
M7	94	4	2	0.69	-1.32	-0.31	1.75
M8	43	45	12	4.63	-3.78	-0.05	0.92
M9	58	31	10	3.42	-3.49	-0.32	1.06
M10	30	64	6	5.00	-2.59	0.02	1.43
M11	71	26	3	2.49	-2.87	-0.41	0.89
M12	63	32	5	2.67	-3.13	-0.36	0.80
M13	34	49	17	5.17	-3.71	0.02	0.83
M14	50	37	13	4.29	-3.78	-0.17	0.84
N1	43	37	19	5.05	-4.17	-0.12	0.79
N2	16	51	34	7.34	-3.53	0.05	1.25
N3	24	48	28	6.44	-4.01	-0.05	0.95
N4	55	35	10	3.33	-3.61	-0.22	1.00
N5	50	44	7	4.01	-3.11	-0.03	1.00
N6	22	64	14	5.72	-3.12	-0.02	1.52
N7	65	28	7	2.52	-3.20	-0.40	0.82
N8	88	9	3	1.39	-1.78	-0.35	1.69
N9	49	45	6	3.75	-3.31	0.09	0.74
N10	46	50	4	3.61	-2.67	0.29	0.84
N11	50	39	11	4.01	-3.67	-0.08	0.81
N12	42	50	8	4.24	-3.48	0.14	0.78
N13	89	10	1	1.80	-1.26	-0.49	3.84
N14	94	4	2	0.62	-1.49	-0.41	4.39
P1	43	42	15	4.76	-3.74	-0.06	0.87
P2	73	23	4	2.81	-2.58	-0.29	0.90
P3	45	43	12	4.42	-3.71	-0.04	0.84
P4	60	34	6	2.82	-3.22	-0.29	0.80

Sample #	Sand%	Silt%	Clay%	Mz	IGSD	Sk1	KG
P5	66	30	4	2.58	-2.91	-0.35	0.68
P7	47	45	8	3.98	-3.32	0.05	0.83
P8	75	21	4	2.13	-2.70	-0.44	0.87
P9	60	34	7	2.75	-3.18	-0.43	0.87
P10	82	12	5	1.61	-2.74	-0.71	2.23
P11	90	8	2	0.77	-1.52	-0.38	1.84
P12	63	30	7	3.35	-3.27	-0.09	0.80
P13	60	33	7	3.38	-3.17	-0.35	1.04
P14	41	44	16	6.08	-5.10	0.45	1.54
PR	30	41	29	6.85	-5.31	-0.12	1.06
Q1	37	49	14	4.83	-3.67	0.05	0.86
Q2	29	47	24	5.82	-4.12	-0.01	0.87
Q3	31	48	21	5.56	-4.09	0.04	0.86
Q4	54	32	13	4.19	-3.50	-0.35	0.94
Q5	37	46	17	4.88	-4.05	0.01	0.84
Q6	51	38	11	4.04	-3.73	-0.14	0.74
Q7	66	31	3	2.60	-2.70	-0.22	0.75
Q9	69	28	3	2.46	-3.05	-0.52	0.75
Q10	52	34	14	4.00	-3.83	-0.21	0.80
Q11	57	34	9	3.38	-3.51	-0.24	0.84
Q12	52	36	12	3.95	-3.79	-0.18	0.89
Q13	40	43	17	5.04	-3.97	0.02	0.86
Q14	96	1	3	0.66	-0.85	-0.22	1.45
R1	46	39	15	4.63	-3.82	-0.11	0.80
R2	43	39	18	4.73	-4.22	-0.06	0.71
R3	44	43	13	4.57	-3.74	0.01	0.85
R4	61	26	13	3.63	-3.65	-0.53	0.90
R5	30	46	24	6.15	-4.22	0.15	0.85
R6	34	47	19	5.41	-3.88	-0.05	0.91
R7	29	48	23	5.90	-3.98	-0.08	0.98

Sample #	Sand%	Silt%	Clay%	Mz	IGSD	Skl	KG
R9	50	38	12	4.10	-3.61	-0.13	0.94
R10	52	32	16	4.65	-3.87	-0.35	1.02
R11	31	53	16	4.94	-3.79	-0.02	0.98
R12	44	45	11	4.25	-3.54	0.06	0.89
R13	40	48	12	4.54	-3.66	0.17	0.85
R14	91	7	2	0.55	-1.63	-0.38	2.16
S2	30	44	27	6.34	-4.37	-0.16	0.91
S3	36	42	22	5.55	-4.15	-0.04	0.80
S4	29	48	23	5.81	-3.99	-0.02	0.93
S5	40	42	18	5.12	-4.10	-0.03	0.83
S6	38	47	15	4.88	-3.76	0.04	0.91
S7	27	58	15	5.50	-3.44	0.12	1.22
S8	34	45	21	5.50	-4.00	0.01	0.81
S9-2	45	51	5	4.00	-2.99	0.17	0.89
S10	11	84	5	5.44	-1.71	-0.14	2.28
S11	38	51	11	4.62	-3.70	0.29	0.76
S12	47	43	10	4.08	-3.68	-0.01	0.84
S13	38	50	12	4.63	-3.69	0.15	0.94
S14	40	49	12	4.13	-5.27	-0.28	1.27
T2	41	36	23	5.18	-4.22	-0.05	0.71
T3	43	44	13	4.60	-3.78	0.01	0.77
T4	47	39	14	4.40	-3.83	-0.08	0.81
T5	43	40	17	4.99	-4.03	-0.08	0.87
T6	34	51	15	5.10	-3.68	0.02	0.94
T7	37	44	19	5.40	-4.09	-0.07	0.93
T8	38	41	21	5.39	-4.25	-0.05	0.86
T9	36	48	16	5.23	-3.70	0.04	0.90
T10	33	47	20	5.44	-3.94	-0.05	0.92
T11	33	42	24	5.67	-4.14	-0.08	0.80
T12	31	50	19	5.85	-3.76	0.18	0.90
T13	47	46	7	3.96	-3.34	0.12	0.78

Sample #	Sand%	Silt%	Clay%	Mz	IGSD	Skl	KG
T14	42	47	11	4.64	-3.55	0.10	0.84
V1	52	34	14	3.98	-4.21	-0.27	0.90
V2	43	40	18	5.04	-4.21	-0.06	0.84
V3	39	39	22	5.40	-4.22	-0.04	0.75
V4	40	40	20	5.52	-4.66	-0.17	0.94
V5	49	38	12	4.30	-3.80	-0.12	0.83
V6	30	41	30	6.37	-4.24	-0.08	0.79
V7	39	39	22	5.41	-4.17	-0.08	0.79
V7.5	29	44	27	6.28	-4.40	-0.11	0.88
V8	42	45	12	4.32	-4.68	-0.13	1.46
V9	33	52	15	5.13	-3.77	0.12	1.00
V10	46	41	12	4.46	-3.69	0.03	0.86
V12	24	59	17	6.02	-3.26	-0.15	1.29
V14	58	36	6	3.40	-3.22	-0.20	0.88
W1	37	41	22	5.54	-4.13	0.02	0.71
W2	37	41	22	5.40	-4.15	-0.01	0.76
W3	47	38	15	4.59	-3.88	-0.07	0.81
W4	49	35	16	4.57	-3.98	-0.11	0.76
W5	44	37	18	4.90	-4.22	-0.04	0.66
W6	27	55	18	5.83	-3.31	-0.13	1.14
W7	30	54	16	6.09	-3.98	0.01	0.84
W8	43	45	12	4.57	-3.67	0.14	0.81
W9	50	32	18	4.64	-4.17	-0.24	0.88
W10	40	43	17	5.17	-4.07	-0.02	0.89
W11	37	44	19	5.25	-4.46	-0.12	0.95
W12	43	42	15	4.84	-3.79	-0.03	0.85
W13	32	52	16	5.51	-3.59	-0.03	1.14
W14	38	46	16	5.14	-3.79	0.05	0.85

APPENDIX IV

GEOCHEMICAL ANALYSES

Geochemical analyses were performed on 269 sediment samples using induced neutron activation (I.N.A.A.) and atomic absorption spectrometry (A.A.S.) techniques. Preliminary preparation of the samples was performed by DNR. This involved dry-sieving the samples with stainless steel sieves to obtain the <0.063 mm fraction (silt and clay), needed in the analyses.

Gold, plus 32 other elements (As, Ba, Br, Ca, Co, Cr, Cs, Fe, Hf, Hg, Ir, Mo, Na, Ni, Rb, Sb, Sc, Se, Sm, Ta, Th, U, W, Zn, La, Ce, Nd, Sn, Eu, Tb, Yb, Lu) were analyzed via induced neutron activation by Activation Laboratory Limited in Ottawa. A 30 gram (1 assay ton) sample of the sediment was encapsulated, irradiated and then measured in a multi-element mode for gold and the other elements. Mercury was added by cold vapour techniques to keep temperatures under 25°C during irradiation. Accuracy and precision of the data were determined by the author from comparison with analyzed standards and duplicate samples (Tables IV.1, and IV.2).

The author had no control over sample preparation methodology. The samples were prepared based on the assumption that organics were a minor constituent. Therefore this component was not removed prior to analysis. Organics tend to absorb neutrons, preventing accurate counts. The samples

Table IV.1 Accuracy of I.N.A.A.

Element	Source	LKSD 1	LKSD 3	LKSD 4
Au	S	5.1 ± 2.4	3.0 ± 2.0	2.5 ± 1.6
(ppb)	A	6 ± 0.5	3	2 ± 0.4
As	S	40 ± 2.0	27 ± 2.0	16 ± 1.0
(ppm)	A	38.3 ± 1.2	26.0 ± 1.6	15.5 ± 0.5
Cr	S	31 ± 3	87 ± 8	33 ± 6
(ppm)	A	31 ± 4.2	83 ± 7.0	34 ± 2.3
Sb	S	1.2 ± 0.1	1.3 ± 0.1	1.7 ± 0.1
(ppm)	A	1.3 ± 0.1	1.2 ± 0.1	1.8 ± 0.1
Zn	S	331 ± 22	152 ± 14	194 ± 19
(ppm)	A	356 ± 21.0	160 ± 8.6	201 ± 6.7

S - N.B.D.N.R.E. Standard values for the element given as mean ± standard deviation

A - Mean ± standard deviation determined by author from I.N.A.A., performed by Activation Laboratory Limited

Table IV.2 Precision of I.N.A.A.

Element	Trial	LKSD 1	LKSD 3	LKSD 4
Au (ppb)	1	(34)	3	2
	2	6	3	3
	3	5	3	2
	4	*	*	2
	A	6 ± 0.5	3	2 ± 0.4
As (ppm)	1	40.0	24.0	16.0
	2	37.0	28.0	15.0
	3	38.0	26.0	15.0
	4	*	*	16.0
	A	38.3 ± 1.2	26.0 ± 1.6	15.5 ± 0.5
Cr (ppm)	1	37	75	30
	2	27	92	35
	3	30	81	34
	4	*	*	36
	A	31 ± 4.2	83 ± 7.0	34 ± 2.3
Sb (ppm)	1	1.4	1.1	1.8
	2	1.2	1.3	1.9
	3	1.2	1.1	1.7
	4	*	*	1.7
	A	1.3 ± 0.1	1.2 ± 0.1	1.8 ± 0.1
Zn (ppm)	1	386	149	209
	2	340	170	200
	3	343	160	205
	4	*	*	191
	A	356 ± 21.0	160 ± 8.6	201 ± 6.7

A - Mean ± standard deviation, determined from trials
* - No trial run
( ) - Value omitted from calculations

analyzed are known to be high in organics and therefore some of the geochemical data may be equivocal.

Base metal contents were determined using atomic absorption spectrometry, performed by the N.B.D.N.R.E. Geochemical Laboratory in Fredericton. One ounce samples of the silt plus clay fractions were used. The base metals were extracted using hot, dilute HNO_3 and analyzed with a spectrometer. Fifteen samples were rerun to determine analytical precision and data quality (Table IV.3).

The data obtained from both techniques were plotted using SURFER®. Elements were plotted individually to determine anomalous dispersal patterns. Significant anomalies were replotted by hand to determine dispersal morphology.

Elements with values below detection limits were listed in the data tables at the detection limit with a negative sign.

Table IV.3 Precision of A.A.S. Analysis*

Sample	Trial #	Elements (ppm) Cu	Mn	Zn	Ni
E4	1	30.4	637.1	63.0	47.1
	2	30.4	629.0	63.0	45.3
	A	30.4	633.0	63.0	46.2
			± 8.1		± 0.9
F14-C2	1	12.6	428.6	34.7	26.1
	2	13.7	476.2	38.3	28.8
	A	13.2	452.4	36.5	27.4
		± 1.1	± 47.6	± 3.6	± 2.7
K7	1	23.9	340.2	61.2	41.4
	2	25.9	356.0	61.2	41.4
	A	24.9	348.1	61.2	41.4
		± 1.0	± 7.9		
P3	1	20.5	593.4	45.3	37.4
	2	20.5	593.4	45.3	37.4
	A	20.5	593.4	45.3	37.4
T9	1	20.2	281.0	34.9	33.8
	2	21.6	290.7	34.9	37.4
	A	20.8	285.8	34.9	35.6
		± 0.7	± 4.8		± 1.8

A - Mean and standard deviation determined from trials

* - A.A.S. performed by N.B.D.N.R.E. Geochemical Laboratory

INDUCED NEUTRON ACTIVATION DATA - PART A

Sample	AU PPB	AS PPM	BA PPM	BR PPM	CO PPM	CR PPM	CS PPM
A1	-2	8.8	340	4.9	11	110	3
A1A	9	18.0	360	6.9	30	81	3
A2	-2	7.7	510	12.0	11	98	3
A3	-2	10.0	470	6.7	13	89	3
A4	-2	13.0	460	10.0	13	90	4
A5	-2	11.0	270	6.7	14	86	3
A6	-2	11.0	300	8.6	13	92	3
A7	-2	8.8	350	22.0	15	100	3
A8	-2	25.0	260	27.0	21	130	4
A9	-2	26.0	340	19.0	29	170	5
A10	-2	32.0	410	27.0	15	170	6
A11	-2	24.0	440	12.0	16	110	4
A12	-2	10.0	490	6.7	13	83	3
A13-1	4	15.0	610	7.6	15	64	3
A13-2	-2	13.0	390	5.5	13	87	4
A14	-2	11.0	410	23.0	12	87	3
B1	-2	12.0	340	24.0	15	100	3
B2	3	11.0	320	19.0	13	110	3
B3	-2	12.0	320	20.0	11	82	4
B4	-2	12.0	350	15.0	20	140	6
B5	-2	76.0	320	24.0	14	100	6
B6	-2	15.0	340	13.0	10	87	5
B7	-2	37.0	370	15.0	25	140	7
B8	-2	28.0	390	18.0	25	140	6
B9	-2	23.0	200	16.0	24	160	4
B10	-2	20.0	470	25.0	17	120	4
B11	4	21.0	420	2.8	20	160	4
B12	-2	9.1	350	24.0	10	85	4
B13	-2	17.0	430	7.9	13	100	4
B14	3	34.0	390	58.0	19	140	5
C1	5	13.0	450	18.0	14	93	5
C1.5	-2	13.0	410	-0.5	15	93	3
C2	4	8.7	400	2.8	12	88	3
C3	-2	8.2	390	4.1	14	89	3

Sample	AU PPB	AS PPM	BA PPM	BR PPM	CO PPM	CR PPM	CS PPM
C4	2	20.0	270	34.0	23	94	5
C5	5	9.4	320	22.0	11	84	4
C6	3	25.0	330	34.0	15	100	6
C7	-2	22.0	350	30.0	15	100	5
C8	-2	16.0	400	5.2	13	98	5
C9	-2	20.0	280	20.0	15	130	4
C10	-2	17.0	280	30.0	10	110	6
C11	-2	7.1	380	36.0	10	86	4
C12	-2	16.0	410	5.9	18	100	4
C13	3	15.0	350	27.0	14	97	4
C14	-2	24.0	370	33.0	14	100	4
D1	-2	9.9	370	19.0	12	95	3
D2	-2	22.0	730	9.0	22	110	6
D3	-2	17.0	380	7.7	13	92	4
D4	-2	12.0	280	30.0	9	78	3
D5	2	25.0	820	11.0	28	140	6
D6	-2	12.0	300	25.0	11	90	4
D7	2	19.0	410	12.0	14	82	5
D8	-2	10.0	440	16.0	13	79	5
D9	-2	25.0	440	5.9	18	180	5
D10	-2	17.0	370	22.0	13	100	5
D11	3	11.0	330	31.0	11	82	5
D12	8	11.0	390	30.0	10	91	5
D13	-2	6.0	360	14.0	14	34	8
D14	-2	8.0	390	-0.5	11	69	5
E1	-2	9.0	450	6.4	11	100	3
E2	-2	11.0	440	11.0	11	110	2
E2H	2	7.0	270	9.2	5	90	2
E3	-2	19.0	560	2.4	16	130	5
E4	-2	15.0	590	3.1	15	130	5
E5	15	37.0	540	21.0	20	170	12
E6	-2	9.6	500	10.0	8	110	5
E7	-2	13.0	480	29.0	15	100	6
E8	-2	14.0	610	19.0	17	100	8
E9	-2	12.0	540	21.0	12	99	9

Sample	AU PPB	AS PPM	BA PPM	BR PPM	CO PPM	CR PPM	CS PPM
E10	-2	14.0	420	26.0	14	120	5
E11	-2	24.0	360	16.0	20	180	6
E12	4	14.0	410	5.8	11	100	5
E13	3	14.0	520	2.8	12	100	6
E14	-2	9.0	330	2.8	13	83	5
F1	-2	15.0	490	23.0	21	110	8
F2	3	16.0	330	35.0	12	150	4
F3	-2	15.0	460	9.8	16	160	5
F4	7	13.0	400	20.0	12	120	4
F5	-2	12.0	450	17.0	12	120	4
F6	5	13.0	560	24.0	9	100	13
F7	-2	15.0	570	19.0	14	120	6
F8	-2	15.0	550	23.0	14	110	9
F9	4	9.1	410	38.0	10	83	9
F10	-2	7.9	390	11.0	9	110	9
F11	-2	22.0	250	20.0	13	120	4
F12	-2	12.0	360	5.8	10	78	7
F13	-2	7.6	510	5.8	10	71	9
F14-C1	-2	9.4	330	3.0	8	67	4
F14-C2	-2	9.0	360	-0.5	9	73	3
G1	-2	11.0	460	3.8	13	110	4
G2	-2	9.2	410	22.0	11	100	5
G3	-2	9.6	380	2.0	11	110	3
G4	15	14.0	530	2.8	14	99	3
G5	6	11.0	490	14.0	12	99	4
G6	-2	6.3	390	5.5	9	92	6
G7	4	11.0	450	4.7	13	100	5
G8	-2	9.1	410	43.0	10	84	7
G9	4	7.4	440	3.8	11	80	7
G10	-2	8.1	240	6.1	8	70	9
G11	-2	8.1	410	24.0	9	57	8
G12	-2	7.2	460	4.2	10	67	8
G13	-2	12.0	430	36.0	10	82	8
G14	3	9.4	570	-0.5	10	59	9
H1	-2	6.3	350	3.0	7	83	3

Sample	AU PPB	AS PPM	BA PPM	BR PPM	CO PPM	CR PPM	CS PPM
H2	-2	10.0	340	11.0	12	99	5
H3	-2	9.9	370	8.7	12	100	3
H4	-2	6.2	380	-0.5	9	85	3
H5	2	5.2	340	8.1	7	87	3
H6	-2	7.9	350	20.0	8	94	3
H7	-2	7.3	330	16.0	6	83	3
H8	3	8.1	290	11.0	8	84	3
H9	-2	11.0	460	5.2	13	87	6
H10	-2	13.0	550	18.0	13	110	8
H11	-2	9.0	350	48.0	9	80	5
H12	-2	10.0	360	42.0	12	83	9
H13	-2	11.0	410	25.0	10	89	7
H14	-2	9.0	460	11.0	10	72	7
K1	-2	6.9	430	5.5	8	99	3
K2	-2	5.9	310	12.0	7	95	2
K3	-2	11.0	440	2.4	11	110	3
K4	4	11.0	480	-0.5	14	100	4
K5A	3	9.1	470	4.8	10	100	4
K5B	-2	9.6	360	21.0	10	100	4
K6	-2	11.0	440	6.3	12	97	4
K7	-2	9.4	370	23.0	13	92	4
K8	-2	13.0	320	13.0	14	100	4
K9	-2	8.3	520	3.0	13	91	5
K10	-2	11.0	380	2.8	14	84	3
K11	-2	10.0	400	8.0	13	81	6
K12	4	11.0	350	38.0	12	92	5
K13	5	10.0	300	77.0	11	80	6
K14	-2	11.0	460	8.4	15	82	5
L1	-2	9.5	360	14.0	14	96	3
L1B	-2	12.0	470	5.4	15	100	4
L2	-2	13.0	290	13.0	13	100	4
L3	-2	13.0	380	3.0	13	92	4
L4	-2	11.0	230	69.0	7	83	3
L5	-2	31.0	370	27.0	19	100	5
L6	-2	9.8	340	-0.5	10	85	4

Sample	AU PPB	AS PPM	BA PPM	BR PPM	CO PPM	CR PPM	CS PPM
L7	-2	8.5	410	9.3	12	87	4
L8	8	7.4	310	12.0	7	76	5
L9	4	5.3	400	7.7	8	85	6
L10	4	1.0	370	2.7	14	81	5
L11	2	15.0	430	-0.5	17	110	5
L12	-2	11.0	500	7.9	15	95	7
L13	2	8.9	330	17.0	12	83	3
L14	-2	14.0	530	4.7	16	89	6
L14A	-2	12.0	300	35.0	10	84	10
M1	4	8.6	290	4.5	12	86	2
M2	-2	10.0	420	5.6	13	93	3
M3	-2	8.6	380	1.4	11	72	3
M4	-2	9.0	320	18.0	11	75	5
M5	-2	10.0	430	16.0	12	83	4
M6	-2	11.0	280	20.0	18	100	10
M7	5	35.0	430	10.0	23	110	5
M8	3	6.0	330	4.2	7	70	4
M9	-2	8.2	370	18.0	11	95	4
M10	-2	10.0	340	1.7	12	80	4
M11	-2	5.2	300	9.3	5	50	7
M12	-2	7.5	310	21.0	11	65	7
M13	-2	9.9	360	7.0	13	89	4
M14	-2	8.9	380	7.5	13	80	5
N1	-2	7.8	390	2.7	11	85	4
N2	4	12.0	470	4.6	15	120	5
N3	2	11.0	420	2.6	13	99	4
N4	3	9.7	450	-0.5	12	73	5
N5	-2	9.8	340	5.0	11	83	5
N6	4	7.0	370	-0.5	11	78	3
N7	-2	9.1	270	23.0	11	70	9
N8	-2	14.0	330	18.0	20	96	3
N9	-2	7.4	320	32.0	9	79	6
N9A	2	1.7	180	-0.5	1	48	3
N10	-2	10.0	340	4.4	10	81	5
N11	2	7.6	360	5.5	12	87	4

Sample	AU PPB	AS PPM	BA PPM	BR PPM	CO PPM	CR PPM	CS PPM
N12	-2	9.2	310	12.0	9	82	4
N13	4	16.0	370	18.0	20	97	3
N14	4	11.0	290	4.4	13	94	2
P1	4	6.7	420	14.0	11	95	2
P2	-2	29.0	300	4.1	24	110	4
P3	-2	11.0	360	9.6	14	100	3
P4	-2	9.9	210	58.0	9	87	4
P5	-2	7.5	250	23.0	8	73	8
P7	3	8.0	300	15.0	9	69	5
P8	-2	8.3	280	9.5	10	64	4
P9	-2	9.8	370	12.0	9	94	3
P10	-2	43.0	-50	61.0	27	110	2
P11	5	39.0	400	14.0	16	130	4
P12	3	9.4	400	5.4	11	71	4
P13	3	6.2	300	13.0	10	71	8
P14	3	7.0	360	8.8	10	77	3
Q1	-2	16.0	370	20.0	14	100	10
Q2	-2	15.0	440	3.1	14	100	6
Q3	-2	9.8	470	2.9	12	110	4
Q4	3	4.7	450	2.3	11	110	3
Q5	-2	8.1	390	19.0	9	100	4
Q6	3	6.8	340	-0.5	8	61	7
Q7	-2	6.1	260	14.0	7	65	8
Q9	-2	6.8	290	15.0	9	74	5
Q10	2	6.9	350	9.1	9	66	8
Q11	-2	9.4	310	18.0	9	62	6
Q12	-2	9.3	340	10.0	10	84	4
Q13	-2	5.8	390	4.0	10	86	4
Q14	-2	28.0	350	18.0	21	100	5
R1	6	25.0	580	5.0	19	150	6
R2	4	12.0	410	18.0	23	130	6
R3	-2	18.0	400	17.0	14	110	5
R4	6	11.0	480	9.5	15	120	6
R5	-2	10.0	370	7.0	11	100	4
R6	-2	7.0	350	2.3	10	93	3

Sample	AU PPB	AS PPM	BA PPM	BR PPM	CO PPM	CR PPM	CS PPM
R7	-2	11.0	520	2.1	14	110	4
R9	3	5.7	350	1.4	9	87	3
R10	2	14.0	400	-0.5	13	100	5
R11	4	6.2	320	2.7	8	83	3
R12	3	9.3	310	38.0	11	96	4
R13	2	7.0	320	16.0	7	86	4
R14	-2	16.0	350	35.0	16	100	5
S2	4	14.0	290	2.1	13	100	6
S3	-2	15.0	410	3.0	11	100	4
S4	-2	16.0	360	5.2	12	95	5
S5	-2	12.0	320	8.7	9	94	5
S6	-2	10.0	300	8.2	9	90	5
S7	-2	13.0	520	17.0	10	140	7
S8	-2	9.8	340	3.9	10	95	4
S9-2	9	7.5	310	1.9	9	79	4
S10	-2	4.5	250	8.2	7	67	5
S11	4	10.0	250	11.0	8	81	4
S12	-2	5.7	340	5.2	8	89	3
S13	2	11.0	310	12.0	13	110	5
S14	2	6.6	300	8.7	10	100	5
T2	2	18.0	370	-0.5	12	82	10
T3	-2	12.0	350	8.8	9	83	5
T4	-2	14.0	410	2.2	12	85	7
T5	-2	9.8	350	5.3	12	94	6
T6	-2	14.0	290	34.0	11	94	5
T7	-2	13.0	420	8.9	12	96	6
T8	4	9.7	390	5.4	11	90	5
T9	-2	9.1	410	-0.5	9	82	4
T10	3	7.7	380	7.4	10	91	5
T11	3	7.7	400	2.3	11	89	4
T12	-2	8.3	340	1.6	12	78	4
T13	-2	5.8	340	12.0	9	69	5
T14	-2	7.3	370	7.0	11	86	4
V1	3	12.0	460	33.0	11	99	6
V2	-2	17.0	460	5.9	12	85	8

Sample	AU PPB	AS PPM	BA PPM	BR PPM	CO PPM	CR PPM	CS PPM
V3	4	22.0	530	-0.5	12	88	10
V4	-2	18.0	370	2.2	11	79	8
V5	-2	15.0	450	2.6	10	71	6
V6	-2	18.0	430	-0.5	11	91	8
V7	-2	12.0	430	4.5	12	94	7
V7.5	3	19.0	610	-0.5	14	100	8
V8	-2	8.1	300	17.0	5	80	4
V9	46	250.0	380	9.7	9	110	5
V10	-2	14.0	240	19.0	10	89	5
V12	2	7.6	350	2.3	7	80	4
V14	-2	4.9	300	4.6	8	76	4
W1	-2	21.0	400	4.5	11	93	7
W2	-2	15.0	460	1.7	11	86	5
W3	-2	19.0	410	4.9	11	75	7
W4	-2	16.0	420	8.2	10	83	7
W5	-2	22.0	530	2.7	13	80	7
W6	-2	7.4	320	-0.5	8	100	3
W7	-2	16.0	460	2.7	13	91	5
W8	3	12.0	390	20.0	8	85	7
W9	2	19.0	420	2.4	13	90	7
W10	8	25.0	440	3.4	12	110	7
W11	9	17.0	400	6.8	9	100	5
W12	-2	16.0	400	7.7	10	90	5
W13	-2	6.9	360	9.5	9	84	3
W14	-2	7.7	350	-0.5	8	79	3

INDUCED NEUTRON ACTIVATION DATA - PART B

Sample	FE %	HF PPM	HG PPB	MO PPM	NA %	NI PPM	RB PPM
A1	3.12	24	55	3	1.42	-21	64
A1A	4.00	12	25	-1	1.37	-24	71
A2	3.21	14	40	-1	1.39	-24	80
A3	3.53	9	50	3	1.11	-24	82
A4	3.91	10	50	-1	1.20	-26	74
A5	3.88	10	30	2	1.28	-25	100
A6	3.37	10	60	-1	1.26	-22	66
A7	3.51	8	105	-1	0.86	-24	-6
A8	3.76	8	85	-1	0.94	120	62
A9	4.85	6	145	-1	0.77	210	66
A10	4.14	8	70	2	0.77	-23	71
A11	3.83	9	50	-1	1.17	-20	96
A12	3.67	14	50	-1	1.43	-20	120
A13-1	3.95	24	55	3	1.57	-21	110
A13-2	3.44	12	50	-1	1.21	-20	81
A14	3.96	12	130	-1	0.91	-20	76
B1	4.15	10	150	-1	1.05	-20	49
B2	3.80	12	80	-1	1.31	-20	72
B3	4.18	12	70	2	0.82	-20	88
B4	5.22	9	75	2	1.54	97	75
B5	4.54	9	50	1	1.22	-21	100
B6	3.48	11	60	2	1.16	-20	98
B7	4.91	6	45	-1	0.92	120	120
B8	4.81	7	75	-1	1.01	75	72
B9	4.34	7	55	-1	0.81	-20	52
B10	4.16	10	95	-1	1.11	100	92
B11	4.36	9	20	-1	1.14	37	98
B12	3.64	11	90	-1	1.21	-20	60
B13	3.54	12	30	2	1.30	-20	82
B14	5.18	8	160	1	0.86	-20	98
C1	3.93	12	80	-1	0.95	80	100
C1.5	3.92	10	25	-1	1.33	-20	87
C2	3.37	11	15	-1	1.39	-20	80
C3	3.38	11	45	-1	1.29	-20	86

Sample	FE %	HF PPM	HG PPB	MO PPM	NA %	NI PPM	RB PPM
C4	4.79	6	135	2	0.54	86	44
C5	3.25	9	120	-1	0.94	-20	59
C6	4.53	8	110	-1	1.42	-20	48
C7	3.86	10	80	-1	1.20	-20	81
C8	3.59	10	25	2	1.29	-20	77
C9	3.77	10	90	-1	0.98	-20	68
C10	4.64	10	145	3	0.95	-20	42
C11	3.20	14	95	2	1.42	-20	92
C12	3.96	9	30	2	1.28	170	91
C13	4.09	9	90	-1	1.14	-20	77
C14	3.81	11	115	-1	1.07	100	67
D1	3.33	9	115	-1	1.16	-20	84
D2	4.94	9	45	2	1.04	-20	130
D3	3.62	10	50	2	1.12	-20	90
D4	4.07	8	115	1	0.93	-20	73
D5	6.12	14	55	3	1.77	-20	140
D6	3.62	10	115	-1	1.00	-20	58
D7	3.96	14	55	-1	1.21	-20	110
D8	4.00	15	90	2	1.27	-20	100
D9	4.70	6	65	2	0.83	-20	71
D10	3.84	10	110	-1	1.14	-20	79
D11	3.11	14	85	6	1.27	-20	89
D12	3.44	9	110	2	1.11	-20	66
D13	5.06	29	30	9	1.96	-30	140
D14	2.90	11	20	3	1.41	-20	69
E1	3.25	11	25	-1	1.17	-20	82
E2	3.19	11	85	-1	1.32	68	59
E2H	3.01	11	25	-1	0.86	-20	54
E3	4.89	11	20	2	1.63	-21	110
E4	4.88	11	25	-1	1.46	160	98
E5	5.81	9	85	3	1.03	52	140
E6	3.66	13	40	2	1.44	120	98
E7	5.15	18	105	4	1.59	-22	140
E8	5.38	15	85	3	1.56	120	130
E9	4.02	15	105	3	1.56	-20	110

Sample	FE %	HF PPM	HG PPB	MO PPM	NA %	NI PPM	RB PPM
E10	4.36	14	180	3	1.42	-20	93
E11	4.64	13	105	-1	1.26	-20	79
E12	3.48	20	50	5	1.88	32	76
E13	3.91	16	80	4	1.79	90	92
E14	3.28	13	35	2	1.55	72	80
F1	4.07	10	105	-1	1.13	80	100
F2	4.04	13	135	-1	1.38	-20	63
F3	4.30	22	50	3	1.40	-20	78
F4	4.08	12	65	-1	1.36	37	75
F5	4.32	10	95	-1	1.05	-20	95
F6	3.90	13	80	9	1.21	100	140
F7	4.36	13	75	3	1.45	-20	120
F8	4.90	13	65	9	1.30	-20	130
F9	3.94	14	95	3	1.47	-20	110
F10	3.09	14	170	2	1.30	120	120
F11	3.37	9	90	2	0.79	98	60
F12	3.53	12	80	2	1.49	-20	93
F13	3.67	14	90	6	1.76	82	130
F14-C1	2.51	12	45	2	1.40	47	66
F14-C2	2.43	18	15	2	1.68	-20	65
G1	3.85	8	30	-1	1.08	-20	90
G2	4.08	8	150	-1	0.90	67	82
G3	3.09	16	40	2	1.26	-20	74
G4	3.48	11	25	2	1.28	-20	88
G5	3.55	10	80	-1	1.20	45	72
G6	2.77	13	45	9	1.39	67	63
G7	3.83	12	50	2	1.29	-20	79
G8	3.92	10	165	3	1.05	-20	120
G9	3.36	12	170	-1	1.51	-20	94
G10	3.05	14	145	3	1.54	-20	130
G11	3.06	10	90	3	1.33	66	100
G12	3.32	12	70	4	1.59	-20	140
G13	3.53	11	255	4	1.36	-20	98
G14	3.25	13	15	6	1.79	-20	160
H1	2.52	12	15	-1	1.41	-20	73

Sample	FE %	HF PPM	HG PPB	MO PPM	NA %	NI PPM	RB PPM
H2	3.32	16	65	3	1.22	100	94
H3	3.40	12	60	2	1.22	80	84
H4	2.70	11	20	3	1.28	-20	66
H5	2.66	11	50	-1	1.27	-20	73
H6	3.30	10	145	-1	0.99	-20	60
H7	3.18	10	75	-1	0.98	-20	68
H8	2.74	12	45	2	1.22	-20	72
H9	3.46	10	45	2	1.21	-20	110
H10	4.50	7	5	4	1.00	-20	130
H11	3.56	11	145	5	1.06	-20	82
H12	3.74	10	155	3	1.15	-20	83
H13	3.59	11	75	10	1.27	-20	99
H14	3.30	11	65	3	1.44	-20	110
K1	3.02	11	35	-1	1.20	-20	72
K2	2.99	15	40	-1	1.37	-20	62
K3	3.55	12	30	2	1.29	-20	84
K4	4.08	9	35	-1	1.16	-20	100
K5A	3.43	11	30	2	1.29	50	95
K5B	3.69	13	150	4	1.20	-20	92
K6	3.56	10	35	2	1.25	-20	77
K7	3.52	10	85	-1	1.31	-20	77
K8	4.02	11	75	9	1.27	-20	110
K9	3.74	10	40	2	1.29	-20	120
K10	3.37	10	35	-1	1.32	-20	71
K11	3.62	13	40	3	1.55	-20	99
K12	3.80	11	125	2	1.22	-20	110
K13	3.59	10	160	3	1.22	-20	86
K14	3.68	12	35	-1	1.42	-20	120
L1	3.80	11	75	-1	1.25	62	93
L1B	4.18	10	45	2	1.17	110	120
L2	3.69	13	70	3	1.26	69	78
L3	3.71	13	30	4	1.42	90	94
L4	6.81	[illegible]	175	-1	0.54	-20	46
L5	4.47	10	110	-1	1.32	88	80
L6	2.87	27	15	4	1.70	35	63

Sample	FE %	HF PPM	HG PPB	MO PPM	NA %	NI PPM	RB PPM
L7	3.37	11	40	3	1.48	-20	100
L8	3.14	12	85	2	1.20	-20	88
L9	2.74	12	25	4	1.39	-20	92
L10	3.38	17	25	3	1.62	-20	110
L11	4.16	15	40	-1	1.41	53	100
L12	4.08	12	20	4	1.24	65	120
L13	3.04	13	40	2	1.35	-20	67
L14	4.35	10	25	-1	1.24	110	120
L14A	5.57	9	80	4	0.83	-20	110
M1	2.66	14	45	2	1.49	-20	47
M2	3.57	12	25	2	1.40	-20	78
M3	2.99	11	75	2	1.36	-20	77
M4	3.29	16	100	3	1.35	-20	91
M5	3.35	11	55	2	1.36	-20	99
M6	4.53	11	105	9	1.28	-20	74
M7	4.63	7	105	-1	1.54	-20	95
M8	2.68	13	30	2	1.50	-20	82
M9	3.31	15	80	2	1.39	-20	91
M10	3.30	12	100	2	1.45	62	82
M11	2.28	13	115	4	1.45	-20	79
M12	3.54	11	175	2	1.34	-20	120
M13	3.60	11	45	-1	1.31	-20	90
M14	3.44	11	60	3	1.44	-20	86
N1	3.44	10	30	-1	1.33	-20	100
N2	4.49	7	35	-1	1.03	-20	110
N3	3.74	10	25	-1	1.28	-20	100
N4	3.33	15	45	3	1.56	-20	110
N5	3.09	17	50	3	1.58	-20	92
N6	3.02	11	15	2	1.57	-20	84
N7	3.52	10	130	2	1.25	-20	120
N8	3.33	15	90	2	1.38	95	74
N9	3.34	11	180	2	1.25	71	76
N9A	0.52	19	10	2	0.84	-20	50
N10	2.98	14	95	2	1.60	-20	77
N11	3.27	13	55	2	1.52	80	91

Sample	FE %	HF PPM	HG PPB	MO PPM	NA %	NI PPM	RB PPM
N12	3.12	14	75	2	1.64	-20	73
N13	3.78	9	150	-1	1.64	-20	84
N14	3.15	21	30	-1	1.46	-20	71
P1	3.12	11	75	-1	1.32	-20	74
P2	3.68	13	30	2	1.78	-20	66
P3	3.46	13	50	-1	1.41	-20	88
P4	3.77	12	215	-1	0.99	-20	58
P5	2.81	11	175	2	1.08	-20	77
P7	2.85	12	90	3	1.42	-20	79
P8	2.49	14	40	2	1.55	70	72
P9	3.37	15	75	-1	1.21	-20	81
P10	3.59	8	225	9	0.61	-20	24
P11	4.94	11	165	2	1.27	-20	59
P12	3.02	12	40	-1	1.47	-20	77
P13	2.87	15	60	4	1.47	-20	110
P14	2.92	11	30	-1	1.29	57	75
Q1	3.60	9	60	3	1.05	-20	99
Q2	3.80	9	20	-1	1.20	-20	100
Q3	3.38	10	25	-1	1.26	-20	87
Q4	3.07	10	20	2	1.25	-20	82
Q5	3.05	10	85	2	0.98	51	79
Q6	2.98	8	15	4	1.40	-20	100
Q7	2.47	11	55	3	1.53	49	99
Q9	2.60	11	30	3	1.50	-20	73
Q10	2.97	10	25	4	1.28	-20	100
Q11	2.74	12	60	3	1.43	-20	94
Q12	2.99	13	35	-1	1.34	-20	78
Q13	3.01	11	35	2	1.26	-20	84
Q14	3.79	9	140	2	1.48	-20	65
R1	5.41	13	20	3	1.72	-20	120
R2	4.44	9	85	2	0.83	-20	100
R3	3.85	8	80	-1	1.07	71	77
R4	3.66	12	135	6	1.07	80	84
R5	3.50	9	45	-1	1.01	-20	85
R6	2.76	11	25	-1	1.24	100	59

Sample	FE %	HF PPM	HG PPB	MO PPM	NA %	NI PPM	RB PPM
R7	3.60	10	35	6	1.23	-20	80
R9	2.48	13	25	2	1.34	-20	68
R10	3.65	10	45	3	1.11	60	90
R11	2.66	11	20	2	1.24	-20	75
R12	3.44	9	200	2	1.02	-20	65
R13	2.76	13	70	2	1.28	86	65
R14	4.30	10	120	-1	0.93	-20	63
S2	3.37	8	10	-1	1.13	-20	85
S3	3.41	9	20	3	1.13	-20	86
S4	3.29	9	25	2	1.02	-20	89
S5	3.21	10	45	2	1.02	-20	83
S6	3.10	10	30	-1	0.02	-20	58
S7	4.68	14	35	2	1.37	-20	140
S8	2.99	10	20	-1	1.04	-20	68
S9-2	2.67	13	20	-1	1.39	43	64
S10	2.13	12	50	2	1.52	-20	56
S11	3.06	9	80	-1	1.02	-20	53
S12	2.60	10	55	-1	1.19	-20	81
S13	3.47	11	100	1	0.99	-20	68
S14	2.61	10	60	2	0.92	63	77
T2	4.01	8	20	3	1.19	51	150
T3	2.72	10	45	-1	1.10	-20	87
T4	3.28	10	25	3	1.39	67	120
T5	3.41	10	40	2	1.24	87	100
T6	3.40	10	75	2	1.09	-20	99
T7	3.51	10	55	2	1.10	-20	100
T8	3.01	12	50	2	1.17	85	79
T9	2.63	11	20	2	1.25	-20	87
T10	3.01	10	40	2	1.22	-20	110
T11	3.26	10	20	2	1.32	-20	100
T12	3.11	10	20	2	1.41	70	76
T13	2.82	11	50	2	1.42	69	71
T14	2.99	10	45	2	1.42	-20	75
V1	3.29	9	120	2	1.03	-20	88
V2	3.52	9	20	3	1.24	-20	130

Sample	FE %	HF PPM	HG PPB	MO PPM	NA %	NI PPM	RB PPM
V3	4.16	9	10	3	1.26	-20	140
V4	3.25	9	15	2	1.20	-20	130
V5	2.82	10	20	3	1.33	-20	100
V6	4.07	8	20	2	1.15	-20	140
V7	3.41	9	20	2	0.98	89	94
V7.5	4.13	7	25	-1	0.97	-20	120
V8	2.27	14	65	2	1.04	-20	77
V9	3.50	10	40	2	0.85	94	89
V10	2.75	9	135	-1	0.86	-20	98
V12	2.74	11	20	4	1.29	-20	71
V14	2.50	11	20	2	1.58	-20	60
W1	3.51	8	20	2	1.10	-20	100
W2	3.46	7	20	3	1.07	61	110
W3	3.16	9	30	3	1.28	-20	110
W4	3.19	9	25	3	1.21	-20	110
W5	3.30	9	35	3	1.27	-20	99
W6	3.03	13	35	-1	1.22	-20	68
W7	3.48	9	30	2	1.15	-20	110
W8	3.30	9	105	2	1.12	-20	110
W9	3.50	9	30	3	1.06	59	100
W10	3.40	9	35	3	0.77	89	100
W11	3.10	11	60	2	1.05	87	72
W12	3.03	8	55	-1	0.98	-20	68
W13	2.80	9	35	-1	1.16	-20	83
W14	2.65	10	70	-1	1.37	-20	66

INDUCED NEUTRON ACTIVATION DATA - PART C

Sample	SB PPM	SC PPM	TA PPM	TH PPM	U PPM	W PPM	ZN PPM
A1	0.7	10.0	1.4	11.0	4.4	-1	-50
A1A	1.7	13.0	2.2	14.0	3.1	-1	149
A2	0.8	11.0	-0.5	12.0	3.6	-1	-50
A3	1.0	12.0	-0.5	10.0	2.5	-1	-50
A4	1.1	12.0	-0.5	11.0	2.8	-1	105
A5	1.1	13.0	-0.5	12.0	3.7	-1	132
A6	0.8	11.0	-0.5	9.4	1.8	4	69
A7	0.4	12.0	-0.5	9.4	2.5	-1	73
A8	0.5	13.0	-0.5	12.0	2.7	-1	53
A9	0.9	17.0	-0.5	12.0	3.3	-1	98
A10	0.8	13.0	-0.5	7.3	1.7	-1	97
A11	1.0	14.0	1.3	11.0	2.6	-1	109
A12	0.8	13.0	0.8	20.0	3.6	-1	108
A13-1	0.7	14.0	1.8	33.0	2.8	-1	74
A13-2	0.8	13.0	1.5	14.0	2.8	2	91
A14	0.7	12.0	-0.5	14.0	3.4	3	-50
B1	0.8	10.0	0.9	10.0	2.8	2	79
B2	0.7	12.0	0.6	10.0	3.5	-1	99
B3	0.9	12.0	-0.5	10.0	3.2	-1	61
B4	0.4	16.0	-0.5	10.0	3.2	-1	138
B5	1.3	17.0	1.3	10.0	2.0	-1	111
B6	0.5	12.0	1.6	9.5	3.6	-1	54
B7	0.7	17.0	1.1	14.0	1.8	-1	114
B8	0.9	17.0	0.8	15.0	2.6	-1	118
B9	0.8	13.0	1.0	8.9	2.5	-1	-50
B10	0.9	14.0	-0.5	11.0	3.0	-1	128
B11	1.1	17.0	-0.5	12.0	2.4	-1	90
B12	0.7	11.0	1.4	11.0	2.5	-1	77
B13	0.8	13.0	-0.5	14.0	3.6	-1	68
B14	1.1	16.0	-0.5	14.0	3.0	-1	129
C1	1.5	14.0	1.5	13.0	2.8	-1	182
C1.5	1.1	14.0	1.3	11.0	1.9	2	60
C2	1.0	12.0	1.3	11.0	2.5	-1	-50
C3	1.0	13.0	1.4	11.0	2.9	2	94

Sample	SB PPM	SC PPM	TA PPM	TH PPM	U PPM	W PPM	ZN PPM
C4	0.4	16.0	1.1	11.0	3.7	-1	92
C5	0.9	11.0	0.5	9.3	2.7	-1	118
C6	0.8	16.0	1.2	9.4	2.4	-1	121
C7	0.8	13.0	0.9	12.0	2.7	-1	63
C8	0.6	14.0	1.2	11.0	3.3	2	64
C9	0.7	12.0	0.7	9.6	2.3	-1	74
C10	0.8	12.0	1.3	9.3	5.2	-1	142
C11	0.6	11.0	1.6	13.0	3.5	-1	56
C12	1.0	14.0	1.0	12.0	3.1	-1	74
C13	0.9	14.0	1.0	13.0	2.6	-1	100
C14	0.9	13.0	1.1	13.0	2.8	-1	91
D1	0.7	12.0	-0.5	9.7	2.2	-1	85
D2	0.9	17.0	1.4	14.0	3.3	-1	191
D3	1.0	14.0	1.0	12.0	3.3	-1	70
D4	0.8	11.0	0.9	9.4	2.1	-1	83
D5	1.4	21.0	1.9	18.0	4.0	-1	142
D6	0.8	11.0	0.8	10.0	1.9	-1	76
D7	0.9	14.0	1.3	17.0	2.8	-1	95
D8	0.8	14.0	1.5	22.0	3.9	2	72
D9	0.9	19.0	-0.5	14.0	3.1	-1	109
D10	0.8	14.0	1.5	14.0	2.7	3	107
D11	0.6	11.0	1.4	21.0	8.8	-1	94
D12	0.7	11.0	1.1	12.0	3.3	-1	106
D13	0.5	21.0	3.3	65.0	13.0	8	179
D14	0.6	13.0	-0.5	21.0	4.1	4	62
E1	0.9	12.0	-0.5	11.0	2.0	-1	76
E2	0.8	11.0	-0.5	12.0	2.7	-1	100
E2H	0.7	9.0	1.5	9.5	2.0	2	88
E3	1.5	18.0	1.9	15.0	3.6	-1	116
E4	1.3	18.0	-0.5	15.0	3.8	-1	113
E5	0.9	22.0	1.0	14.0	4.7	-1	162
E6	0.6	13.0	1.6	13.0	3.0	4	76
E7	1.0	18.0	2.7	26.0	6.9	3	176
E8	0.9	19.0	1.0	31.0	5.5	4	150
E9	0.9	13.0	2.0	21.0	5.5	4	78

Sample	SB PPM	SC PPM	TA PPM	TH PPM	U PPM	W PPM	ZN PPM
E10	0.9	15.0	1.2	19.0	4.0	2	133
E11	0.9	16.0	-0.5	14.0	3.5	3	150
E12	0.9	13.0	1.9	23.0	7.3	5	123
E13	0.9	15.0	-0.5	25.0	6.0	-1	99
E14	0.8	14.0	1.4	20.0	4.6	-1	83
F1	0.8	12.0	-0.5	11.0	4.1	-1	163
F2	0.8	11.0	-0.5	13.0	2.9	2	128
F3	1.0	16.0	-0.5	14.0	4.9	-1	85
F4	0.8	12.0	1.6	12.0	2.9	-1	97
F5	1.0	14.0	1.0	14.0	4.0	-1	114
F6	0.8	15.0	0.9	15.0	12.0	3	87
F7	0.9	16.0	1.7	18.0	4.0	-1	144
F8	1.1	17.0	1.8	23.0	13.0	-1	115
F9	0.8	12.0	2.0	23.0	5.2	5	126
F10	0.8	12.0	-0.5	15.0	3.8	-1	156
F11	0.6	13.0	1.3	11.0	3.2	6	74
F12	0.8	12.0	1.6	19.0	3.7	-1	-50
F13	0.8	13.0	2.7	26.0	5.0	-1	92
F14-C1	0.6	9.6	1.2	14.0	3.4	2	59
F14-C2	0.7	11.0	1.3	16.0	4.2	-1	56
G1	0.9	15.0	1.0	11.0	2.5	-1	76
G2	0.8	12.0	-0.5	11.0	2.8	-1	158
G3	0.9	12.0	-0.5	10.0	3.4	-1	-50
G4	1.0	13.0	1.0	13.0	3.4	3	91
G5	0.8	12.0	0.9	12.0	2.5	-1	75
G6	0.6	12.0	1.3	11.0	12.0	-1	65
G7	0.9	14.0	1.9	16.0	3.3	-1	112
G8	0.6	11.0	1.2	19.0	5.0	-1	96
G9	0.7	11.0	1.4	22.0	4.3	-1	85
G10	0.8	10.0	2.2	26.0	5.2	-1	-50
G11	0.7	11.0	1.2	28.0	5.3	-1	126
G12	0.9	11.0	1.6	31.0	6.2	-1	88
G13	0.5	11.0	1.3	23.0	6.8	5	97
G14	0.9	13.0	2.5	30.0	8.0	4	95
H1	0.7	10.0	1.3	12.0	3.1	-1	-50

Sample	SB PPM	SC PPM	TA PPM	TH PPM	U PPM	W PPM	ZN PPM
H2	0.9	12.0	0.9	27.0	5.6	-1	57
H3	0.9	12.0	-0.5	12.0	3.1	-1	82
H4	0.6	9.8	1.2	10.0	5.3	-1	70
H5	0.7	10.0	1.3	12.0	2.7	-1	68
H6	0.6	9.7	-0.5	9.8	2.8	5	87
H7	0.5	9.6	1.2	9.5	3.3	3	79
H8	0.6	9.5	-0.5	11.0	3.5	3	68
H9	0.9	12.0	1.6	19.0	3.8	4	75
H10	1.0	13.0	1.0	14.0	5.9	-1	126
H11	0.7	10.0	-0.5	16.0	7.4	-1	104
H12	0.9	12.0	1.5	22.0	5.4	-1	110
H13	0.7	12.0	1.1	17.0	15.0	-1	118
H14	0.8	11.0	1.9	24.0	5.3	2	84
K1	0.6	11.0	1.5	10.0	2.9	-1	64
K2	0.7	10.0	1.3	13.0	2.9	3	74
K3	0.8	13.0	1.0	12.0	2.5	2	71
K4	1.0	15.0	1.0	14.0	3.1	3	96
K5A	0.9	13.0	1.8	14.0	3.9	-1	91
K5B	0.7	11.0	1.1	12.0	4.3	-1	103
K6	1.0	13.0	1.4	14.0	3.6	-1	83
K7	0.8	12.0	1.3	13.0	2.2	-1	73
K8	1.0	13.0	1.2	13.0	14.0	-1	76
K9	0.8	13.0	1.3	14.0	4.9	2	68
K10	0.9	13.0	1.0	12.0	2.7	-1	59
K11	1.0	13.0	1.2	23.0	5.1	-1	66
K12	0.9	13.0	1.2	15.0	4.9	-1	89
K13	0.9	12.0	1.2	18.0	6.2	-1	85
K14	0.8	14.0	1.5	20.0	5.0	3	106
L1	1.0	13.0	1.0	10.0	3.0	-1	80
L1B	1.1	16.0	1.7	12.0	5.6	-1	107
L2	0.9	12.0	1.4	13.0	3.9	-1	99
L3	1.0	15.0	1.3	15.0	7.0	-1	-50
L4	0.6	9.4	1.3	9.1	3.7	-1	86
L5	1.3	14.0	-0.5	14.0	3.2	-1	132
L6	0.9	12.0	1.6	27.0	6.0	-1	102

Sample	SB PPM	SC PPM	TA PPM	TH PPM	U PPM	W PPM	ZN PPM
L7	0.8	11.0	1.5	16.0	4.3	-1	71
L8	0.9	10.0	0.9	15.0	4.0	-1	79
L9	0.4	10.0	1.5	12.0	6.9	-1	72
L10	1.0	14.0	1.3	23.0	3.9	-1	85
L11	1.3	17.0	0.9	17.0	4.3	-1	90
L12	0.9	16.0	2.1	22.0	4.3	-1	109
L13	0.7	10.0	1.0	11.0	3.0	-1	71
L14	1.2	17.0	1.0	17.0	4.1	-1	97
L14A	0.9	12.0	1.3	14.0	7.9	4	90
M1	1.1	9.6	1.1	10.0	3.0	3	-50
M2	1.2	13.0	1.1	12.0	2.0	-1	-50
M3	0.9	12.0	1.2	12.0	3.2	-1	60
M4	0.9	11.0	1.4	22.0	4.6	-1	98
M5	0.9	12.0	1.3	14.0	4.0	-1	106
M6	0.7	12.0	-0.5	15.0	12.0	-1	85
M7	1.7	16.0	1.1	17.0	3.6	-1	115
M8	0.6	9.3	1.3	14.0	3.6	-1	80
M9	0.6	11.0	-0.5	13.0	4.3	2	82
M10	0.9	13.0	1.4	15.0	3.0	-1	75
M11	0.6	8.3	2.3	18.0	6.3	-1	54
M12	0.8	12.0	1.5	18.0	3.2	4	111
M13	1.0	12.0	1.2	14.0	2.9	-1	70
M14	0.9	14.0	1.1	15.0	4.2	-1	76
N1	1.0	13.0	1.1	12.0	2.5	3	-50
N2	1.3	16.0	1.2	12.0	2.6	-1	92
N3	1.0	14.0	0.6	11.0	4.0	-1	68
N4	1.1	13.0	1.9	20.0	4.0	-1	75
N5	1.0	11.0	2.0	20.0	4.5	-1	62
N6	0.9	12.0	1.8	13.0	3.4	-1	62
N7	0.9	10.0	1.7	16.0	3.9	-1	108
N8	0.9	13.0	1.1	14.0	4.1	-1	97
N9	0.7	9.6	1.4	12.0	3.0	-1	90
N9A	0.5	5.5	1.8	13.0	4.2	-1	-50
N10	0.8	10.0	1.2	16.0	4.3	3	-50
N11	0.9	12.0	1.3	15.0	4.3	-1	76

Sample	SB PPM	SC PPM	TA PPM	TH PPM	U PPM	W PPM	ZN PPM
N12	0.8	11.0	1.3	17.0	3.8	-1	79
N13	0.9	12.0	1.1	12.0	2.8	-1	74
N14	0.9	11.0	1.4	12.0	3.3	-1	72
P1	0.9	11.0	1.0	10.0	2.7	-1	62
P2	0.8	13.0	1.4	12.0	3.5	-1	87
P3	1.1	12.0	1.0	11.0	3.1	-1	81
P4	0.6	10.0	1.0	16.0	2.8	-1	72
P5	0.9	8.8	1.1	13.0	3.4	-1	96
P7	0.8	10.0	1.8	16.0	4.3	-1	64
P8	0.6	9.2	1.2	15.0	3.6	-1	-50
P9	0.7	11.0	1.3	10.0	1.8	-1	114
P10	0.6	13.0	-0.5	15.0	14.0	-1	67
P11	1.3	25.0	1.1	15.0	3.4	-1	90
P12	0.8	11.0	1.6	18.0	4.3	-1	60
P13	0.7	10.0	1.7	21.0	6.9	-1	64
P14	0.8	11.0	-0.5	11.0	2.9	-1	54
Q1	1.2	11.0	1.3	13.0	4.5	-1	75
Q2	1.5	13.0	0.9	12.0	2.7	-1	81
Q3	1.0	13.0	-0.5	11.0	3.5	-1	-50
Q4	0.6	14.0	1.1	10.0	3.7	-1	71
Q5	0.8	11.0	1.0	9.9	3.1	-1	110
Q6	0.8	11.0	1.8	16.0	5.6	-1	89
Q7	0.6	8.1	1.7	17.0	4.6	-1	-50
Q9	0.7	9.4	1.8	16.0	4.2	-1	-50
Q10	0.7	9.9	1.5	17.0	5.9	-1	-50
Q11	0.7	9.0	2.0	18.0	3.6	-1	54
Q12	0.8	10.0	1.3	14.0	2.9	-1	-50
Q13	0.8	10.0	1.3	11.0	3.7	-1	61
Q14	1.0	12.0	1.2	18.0	3.9	-1	77
R1	2.6	19.0	1.2	17.0	5.6	-1	60
R2	1.4	15.0	1.2	13.0	3.5	-1	17[illegible]
R3	1.2	12.0	0.9	11.0	2.5	-1	9[illegible]
R4	1.1	13.0	-0.5	12.0	8.5	-1	126
R5	1.1	12.0	1.1	11.0	2.6	-1	73
R6	0.9	11.0	1.4	9.5	2.2	-1	80

Sample	SB PPM	SC PPM	TA PPM	TH PPM	U PPM	W PPM	ZN PPM
R7	1.2	14.0	1.3	11.0	8.5	-1	68
R9	0.6	9.8	0.7	11.0	3.1	-1	55
R10	1.3	14.0	1.2	11.0	5.7	-1	97
R11	0.7	9.3	1.2	11.0	3.7	-1	57
R12	0.7	9.9	1.3	11.0	2.0	3	104
R13	0.9	8.9	1.5	11.0	3.3	-1	87
R14	0.7	11.0	-0.5	13.0	2.4	-1	61
S2	1.4	13.0	1.5	11.0	2.8	-1	88
S3	1.5	12.0	0.7	11.0	4.4	-1	59
S4	1.5	12.0	1.1	11.0	3.9	-1	61
S5	1.1	10.0	0.8	11.0	2.7	-1	77
S6	1.1	11.0	1.7	12.0	4.6	-1	64
S7	1.4	14.0	1.2	14.0	3.4	-1	99
S8	1.1	11.0	1.0	11.0	2.8	-1	59
S9-2	1.2	11.0	1.0	14.0	2.8	-1	56
S10	0.7	8.0	0.9	15.0	3.2	-1	-50
S11	0.8	8.6	0.7	10.0	2.7	-1	62
S12	0.6	9.3	1.3	11.0	2.8	-1	74
S13	0.9	10.0	1.2	11.0	2.5	-1	-50
S14	0.8	9.3	-0.5	8.8	3.4	-1	96
T2	1.4	14.0	1.7	18.0	4.8	-1	79
T3	1.1	9.8	1.5	13.0	2.9	-1	69
T4	1.3	13.0	2.4	16.0	5.8	4	68
T5	1.1	13.0	1.5	13.0	3.8	-1	88
T6	1.2	12.0	1.0	11.0	2.8	-1	72
T7	1.3	13.0	1.3	13.0	3.3	-1	67
T8	1.1	12.0	1.1	13.0	3.0	4	62
T9	1.2	11.0	0.9	11.0	3.5	4	-50
T10	0.8	12.0	1.1	11.0	3.0	-1	76
T11	1.1	13.0	1.2	13.0	3.3	-1	73
T12	1.0	12.0	-0.5	12.0	3.0	-1	72
T13	0.7	8.8	1.5	12.0	3.4	-1	50
T14	1.0	11.0	1.4	13.0	3.7	-1	62
V1	1.4	12.0	1.2	14.0	3.4	-1	113
V2	1.2	13.0	2.1	18.0	4.4	4	104

Sample	SB PPM	SC PPM	TA PPM	TH PPM	U PPM	W PPM	ZN PPM
V3	1.3	15.0	2.1	18.0	5.6	4	102
V4	1.2	13.0	1.5	16.0	3.6	3	67
V5	1.0	11.0	1.9	18.0	4.6	-1	62
V6	1.6	15.0	1.7	16.0	3.7	3	105
V7	1.3	13.0	1.3	14.0	3.0	2	68
V7.5	1.4	15.0	1.6	13.0	2.5	-1	97
V8	0.6	8.3	1.2	11.0	3.4	2	54
V9	31.0	10.0	1.2	9.5	3.5	5	123
V10	2.2	10.0	1.1	12.0	2.8	3	81
V12	0.7	11.0	1.4	12.0	6.0	-1	-50
V14	0.6	8.4	1.8	12.0	3.0	3	-50
W1	1.4	13.0	1.3	16.0	3.6	-1	85
W2	0.9	13.0	1.3	13.0	4.4	-1	90
W3	1.0	12.0	1.8	17.0	4.1	2	55
W4	1.0	12.0	1.5	18.0	4.0	-1	80
W5	1.3	13.0	2.0	15.0	4.1	3	73
W6	0.6	11.0	0.9	11.0	2.7	-1	58
W7	1.4	14.0	1.4	16.0	3.5	-1	63
W8	3.4	11.0	1.4	14.0	3.4	4	87
W9	1.5	13.0	1.1	14.0	4.8	4	87
W10	5.9	13.0	1.9	13.0	4.6	8	92
W11	2.6	11.0	1.7	12.0	3.5	-1	84
W12	1.8	11.0	1.0	12.0	2.5	-1	59
W13	0.8	9.7	1.0	12.0	3.0	-1	69
W14	0.9	10.0	1.3	12.0	2.6	-1	-50

INDUCED NEUTRON ACTIVATION DATA - PART D

Sample	LA PPM	CE PPM	ND PPM	SM PPM	EU PPM	TB PPM	YB PPM	LU PPM
A1	42	89	37	7.1	1.6	-0.5	4.3	0.77
A1A	42	150	38	6.7	1.6	1.1	3.6	0.64
A2	43	91	34	6.6	1.6	-0.5	3.5	0.60
A3	36	76	26	5.7	1.2	-0.5	2.9	0.49
A4	40	85	32	5.7	1.2	-0.5	2.8	0.51
A5	42	96	35	5.8	1.4	0.6	3.1	0.50
A6	36	87	31	5.5	1.2	-0.5	2.7	0.50
A7	28	98	23	4.2	1.1	-0.5	2.1	0.40
A8	26	130	20	4.4	1.2	-0.5	2.3	0.40
A9	29	120	23	3.6	0.8	-0.5	2.0	0.32
A10	20	68	15	3.5	1.0	-0.5	2.1	0.34
A11	37	94	28	6.6	1.5	-0.5	3.4	0.56
A12	62	140	56	10.0	1.7	1.3	4.8	0.78
A13-1	93	200	80	16.0	2.2	2.2	5.9	0.99
A13-2	46	100	35	7.1	1.4	1.0	3.3	0.57
A14	47	100	38	8.1	1.6	0.8	3.7	0.64
B1	29	82	21	4.1	1.0	0.8	2.4	0.41
B2	36	110	28	5.6	1.3	0.8	3.2	0.55
B3	35	75	24	5.0	1.1	-0.5	3.0	0.54
B4	31	87	22	4.4	1.2	0.6	2.5	0.47
B5	37	82	28	5.9	1.5	0.8	3.2	0.57
B6	36	78	30	5.0	1.2	1.0	3.0	0.51
B7	43	120	36	6.5	1.6	0.9	3.1	0.46
B8	49	150	41	7.6	1.8	-0.5	3.3	0.57
B9	21	88	16	2.9	0.8	-0.5	1.9	0.34
B10	33	100	29	5.5	1.4	0.7	3.0	0.52
B11	53	96	49	8.8	2.1	1.0	4.0	0.67
B12	37	84	31	5.7	1.3	0.7	3.0	0.53
B13	52	110	40	8.3	1.8	1.1	4.3	0.69
B14	36	120	32	6.9	1.6	1.3	3.1	0.44
C1	45	94	39	6.6	1.5	0.9	3.7	0.66
C1.5	45	89	37	7.3	1.6	0.9	3.7	0.63
C2	42	88	31	5.9	1.3	0.7	3.2	0.55
C3	42	86	30	5.9	1.4	-0.5	3.0	0.52

Sample	LA PPM	CE PPM	ND PPM	SM PPM	EU PPM	TB PPM	YB PPM	LU PPM
C4	49	150	49	11.0	2.8	1.5	5.8	0.95
C5	33	73	25	4.8	1.1	-0.5	2.7	0.44
C6	30	67	25	4.8	1.2	0.8	2.9	0.47
C7	36	94	27	5.3	1.2	0.7	3.0	0.54
C8	38	87	32	5.9	1.4	0.7	3.3	0.56
C9	27	110	17	3.9	0.9	-0.5	2.3	0.41
C10	28	78	28	4.8	1.2	0.8	3.1	0.50
C11	43	110	33	7.1	1.5	0.9	3.8	0.63
C12	40	94	29	5.8	1.4	-0.5	3.0	0.49
C13	42	90	30	6.4	1.3	0.8	3.4	0.57
C14	40	94	34	6.3	1.4	1.0	3.2	0.54
D1	34	76	28	4.9	1.1	0.7	2.6	0.46
D2	44	120	35	6.8	1.5	1.0	3.9	0.64
D3	38	97	30	5.7	1.3	0.9	3.2	0.56
D4	30	64	24	4.6	1.0	0.6	2.5	0.43
D5	58	130	43	9.2	2.1	1.0	5.1	0.86
D6	33	71	24	4.7	1.1	0.5	2.8	0.50
D7	44	140	28	6.1	1.4	-0.5	3.2	0.55
D8	50	120	42	6.8	1.4	0.8	3.5	0.57
D9	33	130	26	5.2	1.4	1.0	2.7	0.42
D10	36	100	31	5.3	1.3	0.9	2.9	0.48
D11	46	160	36	7.7	1.5	1.2	4.2	0.67
D12	35	83	22	5.2	1.2	0.9	2.9	0.44
D13	110	270	73	14.0	2.1	2.9	8.3	1.36
D14	56	140	44	8.5	1.5	1.1	4.1	0.68
E1	37	79	30	5.3	1.3	0.7	3.1	0.52
E2	36	86	28	5.1	1.2	0.8	3.0	0.49
E2H	33	67	27	4.5	1.0	-0.5	2.8	0.44
E3	55	100	50	8.8	2.2	1.5	5.1	0.75
E4	48	99	41	6.8	1.7	1.0	3.7	0.63
E5	35	85	27	5.8	1.6	1.2	4.3	0.69
E6	45	90	35	6.3	1.4	0.8	3.9	0.65
E7	70	160	61	11.0	2.2	2.0	6.9	1.05
E8	72	170	55	10.0	1.9	1.5	5.2	0.76
E9	51	110	43	7.1	1.4	1.1	4.3	0.72

Sample	LA PPM	CE PPM	ND PPM	SM PPM	EU PPM	TB PPM	YB PPM	LU PPM
E10	47	110	38	6.4	1.5	1.3	3.5	0.56
E11	36	150	35	5.9	1.4	1.0	3.8	0.58
E12	52	110	41	7.6	1.6	1.2	4.9	0.77
E13	57	140	51	9.0	1.8	1.4	5.5	0.86
E14	53	120	42	8.4	1.6	1.2	4.7	0.72
F1	39	83	35	5.7	1.4	-0.5	3.3	0.52
F2	34	79	26	5.1	1.2	0.6	3.2	0.54
F3	42	100	33	7.2	1.8	1.2	5.1	0.77
F4	40	83	30	5.7	1.3	0.8	3.5	0.55
F5	40	83	32	5.6	1.3	0.9	3.3	0.50
F6	57	110	55	11.0	2.5	1.8	6.3	0.92
F7	52	120	44	8.2	1.7	1.3	4.7	0.71
F8	53	120	47	8.2	1.6	1.3	4.9	0.69
F9	51	110	42	7.3	1.5	1.1	4.1	0.69
F10	44	89	39	6.0	1.3	-0.5	3.6	0.62
F11	28	97	25	5.2	1.3	0.9	2.9	0.44
F12	44	91	35	6.2	1.2	1.0	3.6	0.58
F13	60	120	44	7.9	1.4	1.0	4.2	0.65
F14-C1	35	84	27	5.1	1.1	0.7	3.2	0.53
F14-C2	48	98	41	8.0	1.6	1.4	5.0	0.79
G1	34	75	32	5.0	1.2	0.8	2.9	0.48
G2	31	66	22	4.2	1.0	0.6	2.4	0.43
G3	38	71	37	7.8	2.0	1.1	4.3	0.64
G4	43	95	37	6.4	1.5	1.1	3.5	0.61
G5	36	79	28	5.1	1.1	0.9	3.0	0.47
G6	48	89	41	7.4	1.7	1.0	3.8	0.59
G7	45	96	41	6.8	1.6	1.2	4.1	0.68
G8	40	85	34	6.3	1.3	1.1	3.3	0.57
G9	54	120	43	7.6	1.3	1.3	4.2	0.63
G10	55	120	46	8.0	1.2	1.2	4.6	0.71
G11	47	110	45	7.6	1.1	1.1	3.8	0.59
G12	60	130	50	9.1	1.3	1.0	4.2	0.67
G13	44	150	35	6.7	1.2	1.1	3.7	0.58
G14	63	140	58	10.0	1.6	1.6	5.5	0.81
H1	51	88	37	6.6	1.5	1.1	3.7	0.57

Sample	LA PPM	CE PPM	ND PPM	SM PPM	EU PPM	TB PPM	YB PPM	LU PPM
H2	39	130	30	5.2	1.2	0.9	3.6	0.61
H3	40	95	38	6.6	1.7	1.1	3.9	0.60
H4	38	76	33	5.3	1.2	-0.5	3.1	0.47
H5	39	78	30	5.8	1.4	1.0	3.5	0.54
H6	32	68	26	4.4	1.0	-0.5	2.7	0.46
H7	34	76	29	5.4	1.3	0.9	3.3	0.49
H8	35	73	26	4.9	1.1	0.7	3.0	0.50
H9	42	93	34	6.3	1.3	0.9	3.4	0.56
H10	35	82	31	5.3	1.2	1.0	3.0	0.46
H11	36	79	30	5.3	1.2	0.9	3.3	0.51
H12	40	94	33	6.4	1.2	1.2	4.1	0.62
H13	42	82	35	6.5	1.3	1.1	4.5	0.65
H14	47	100	40	6.9	1.3	1.2	4.0	0.62
K1	35	72	30	4.8	1.1	0.7	3.1	0.49
K2	38	78	31	5.4	1.3	0.8	3.5	0.53
K3	42	87	35	6.7	1.6	1.0	4.1	0.60
K4	51	91	36	7.2	1.8	1.2	3.8	0.61
K5A	43	91	33	6.2	1.5	1.1	3.8	0.58
K5B	36	79	31	5.5	1.3	1.0	3.6	0.58
K6	40	88	35	5.6	1.3	0.8	3.3	0.51
K7	38	84	29	5.5	1.1	0.9	2.7	0.51
K8	40	86	34	6.6	1.5	1.0	3.3	0.55
K9	41	81	32	5.7	1.1	0.6	3.0	0.51
K10	42	96	27	6.0	1.2	-0.5	3.1	0.49
K11	47	210	37	6.8	1.5	1.0	3.9	0.63
K12	41	90	30	6.2	1.3	0.9	3.3	0.57
K13	40	91	28	6.6	1.3	0.8	3.6	0.54
K14	45	110	35	6.8	1.3	1.1	3.6	0.61
L1	37	81	28	5.8	1.4	0.8	3.2	0.53
L1B	40	82	36	6.4	1.6	0.9	3.7	0.57
L2	36	110	30	5.7	1.3	0.8	3.4	0.56
L3	61	130	44	8.4	1.7	1.1	4.1	0.66
L4	20	46	11	3.2	0.8	0.8	1.9	0.34
L5	35	120	27	5.6	1.4	0.9	2.9	0.51
L6	56	130	49	9.3	1.7	1.3	5.5	0.96

Sample	LA PPM	CE PPM	ND PPM	SM PPM	EU PPM	TB PPM	YB PPM	LU PPM
L7	41	93	35	5.7	1.2	0.9	3.2	0.50
L8	39	91	33	5.7	1.1	0.6	3.2	0.57
L9	41	83	32	6.1	1.1	0.8	3.5	0.60
L10	48	150	43	8.4	1.8	1.1	4.7	0.83
L11	51	110	45	8.8	1.9	1.3	4.6	0.77
L12	50	120	41	7.6	1.4	1.1	3.9	0.68
L13	34	77	28	5.1	1.2	0.9	2.9	0.56
L14	44	100	37	6.6	1.4	0.8	3.3	0.59
L14A	38	83	31	5.0	1.0	-0.5	2.7	0.47
M1	32	83	21	4.7	1.1	0.7	3.0	0.51
M2	39	89	33	5.9	1.3	-0.5	3.3	0.55
M3	39	87	33	6.2	1.3	0.9	3.5	0.59
M4	45	120	39	6.9	1.3	1.3	3.9	0.68
M5	38	90	28	5.7	1.2	0.7	3.3	0.54
M6	32	72	25	4.6	1.0	0.6	2.8	0.49
M7	37	200	35	6.6	1.6	1.1	3.0	0.50
M8	39	97	29	5.3	1.1	0.7	3.1	0.55
M9	38	88	36	6.6	1.5	0.9	3.9	0.65
M10	47	100	36	7.1	1.4	0.9	3.6	0.60
M11	42	92	35	6.6	1.2	0.7	3.6	0.64
M12	38	91	30	5.6	1.1	0.8	3.1	0.54
M13	44	98	36	6.4	1.3	-0.5	3.3	0.54
M14	50	130	39	7.4	1.4	1.0	3.5	0.61
N1	39	83	28	5.6	1.3	0.7	3.1	0.51
N2	39	85	30	5.4	1.1	-0.5	2.9	0.51
N3	40	88	31	6.4	1.5	0.7	3.3	0.60
N4	68	130	50	9.6	1.9	1.6	4.6	0.63
N5	46	110	35	6.8	1.3	0.9	4.0	0.71
N6	46	100	37	7.1	1.5	1.1	3.6	0.57
N7	40	100	31	5.6	1.0	0.6	3.1	0.56
N8	36	100	29	6.4	1.5	0.9	3.5	0.61
N9	34	70	27	4.8	1.0	0.6	2.7	0.50
N9A	43	88	32	5.5	1.1	0.7	3.9	0.66
N10	40	96	32	5.8	1.2	0.7	3.6	0.62
N11	44	110	37	6.3	1.4	0.9	3.4	0.58

Sample	LA PPM	CE PPM	ND PPM	SM PPM	EU PPM	TB PPM	YB PPM	LU PPM
N12	50	110	39	7.2	1.4	0.9	3.8	0.64
N13	30	88	24	5.1	1.3	0.7	2.7	0.47
N14	36	79	31	5.9	1.3	0.9	3.8	0.64
P1	34	71	28	5.1	1.1	0.6	2.9	0.51
P2	40	94	33	6.2	1.4	0.9	3.2	0.58
P3	40	87	34	5.8	1.3	0.9	3.3	0.60
P4	36	87	29	5.9	1.1	0.7	3.5	0.58
P5	32	71	26	4.7	0.9	-0.5	2.9	0.51
P7	41	100	34	6.3	1.2	0.9	3.5	0.60
P8	40	98	34	5.9	1.1	0.8	3.3	0.58
P9	35	76	30	5.4	1.3	0.7	3.5	0.57
P10	35	140	33	8.5	2.1	1.2	3.7	0.59
P11	41	240	42	12.0	2.8	2.2	6.0	0.92
P12	43	110	33	6.8	1.3	1.1	4.2	0.69
P13	50	130	40	8.0	1.2	1.0	4.8	0.79
P14	36	75	32	5.3	1.1	0.6	3.0	0.50
Q1	35	81	24	4.7	1.2	1.1	3.1	0.48
Q2	35	80	24	4.6	1.1	0.8	3.1	0.50
Q3	40	88	26	5.4	1.5	1.0	3.4	0.55
Q4	35	83	26	5.4	1.4	0.9	3.5	0.59
Q5	30	70	23	4.4	1.2	0.7	3.0	0.50
Q6	39	82	25	5.9	1.3	1.1	3.5	0.61
Q7	36	88	23	4.5	0.9	0.8	3.0	0.54
Q9	41	98	28	5.6	1.2	0.8	3.5	0.57
Q10	40	95	27	5.5	1.1	1.0	3.6	0.60
Q11	40	110	28	6.4	1.3	1.2	4.4	0.69
Q12	36	80	25	4.9	1.1	0.8	3.6	0.57
Q13	35	78	23	4.5	1.1	1.0	3.0	0.53
Q14	27	120	24	5.0	1.3	1.1	3.4	0.51
R1	51	130	36	7.1	1.7	1.0	4.7	0.74
R2	35	79	27	5.7	1.5	0.9	3.5	0.58
R3	31	73	22	4.2	1.1	0.7	2.8	0.45
R4	35	94	26	5.0	1.4	-0.5	3.5	0.57
R5	30	67	21	3.9	1.0	0.5	2.6	0.44
R6	31	73	21	4.3	1.1	0.6	3.0	0.52

Sample	LA PPM	CE PPM	ND PPM	SM PPM	EU PPM	TB PPM	YB PPM	LU PPM
R7	38	83	30	5.7	1.5	1.0	3.8	0.61
R9	34	79	26	4.8	1.3	0.8	3.4	0.59
R10	35	73	25	5.6	1.5	1.2	3.8	0.64
R11	33	73	25	4.6	1.1	0.7	3.1	0.55
R12	28	71	22	3.9	1.0	0.7	2.8	0.44
R13	34	75	24	4.4	1.1	0.8	3.0	0.54
R14	25	61	22	3.7	1.0	-0.5	2.6	0.44
S2	33	69	22	4.2	1.1	0.8	2.9	0.47
S3	32	70	22	4.1	1.0	0.6	2.9	0.46
S4	32	74	23	4.1	1.1	-0.5	2.8	0.47
S5	28	63	22	3.9	1.0	0.6	3.0	0.50
S6	33	70	25	4.8	1.1	0.9	3.0	0.48
S7	44	100	31	5.7	1.5	0.9	4.1	0.66
S8	30	71	21	4.0	1.1	0.7	2.8	0.47
S9-2	44	94	34	7.0	1.6	1.4	4.3	0.70
S10	35	82	24	4.5	1.0	0.7	3.2	0.55
S11	31	72	22	3.9	1.0	-0.5	2.7	0.49
S12	34	79	29	4.7	1.3	0.7	3.1	0.49
S13	29	71	21	3.9	1.1	0.9	2.9	0.53
S14	29	62	20	3.6	1.0	0.6	2.8	0.44
T2	45	91	32	6.6	1.5	1.3	4.0	0.70
T3	34	77	25	4.6	1.1	0.9	3.2	0.50
T4	49	100	39	7.6	1.5	0.9	3.7	0.59
T5	36	83	24	5.4	1.1	0.7	3.1	0.54
T6	37	80	27	5.6	1.3	0.6	3.1	0.52
T7	35	80	29	5.5	1.2	0.8	3.0	0.53
T8	38	81	31	5.8	1.2	0.9	3.4	0.58
T9	44	86	36	6.2	1.4	0.9	3.1	0.57
T10	36	72	27	5.3	1.1	0.6	2.8	0.46
T11	39	87	32	5.5	1.2	0.7	3.0	0.55
T12	46	95	42	7.5	1.6	1.1	3.8	0.65
T13	41	97	31	6.2	1.2	1.0	3.3	0.54
T14	42	93	32	6.3	1.3	0.8	3.2	0.57
V1	36	74	29	5.7	1.3	-0.5	3.1	0.49
V2	42	95	33	6.2	1.3	1.0	3.4	0.56

Sample	LA PPM	CE PPM	ND PPM	SM PPM	EU PPM	TB PPM	YB PPM	LU PPM
V3	51	99	43	8.0	1.6	1.2	4.4	0.72
V4	41	92	34	6.0	1.3	0.9	3.5	0.50
V5	46	110	36	6.3	1.2	1.0	3.5	0.57
V6	45	87	37	7.3	1.6	1.2	3.9	0.64
V7	37	84	30	5.3	1.1	0.8	3.1	0.50
V7.5	44	86	44	7.5	1.8	1.2	4.1	0.60
V8	35	71	28	5.1	1.2	0.8	3.5	0.53
V9	36	77	30	5.1	1.2	0.8	3.3	0.55
V10	32	63	23	4.7	1.1	0.8	3.0	0.46
V12	39	78	31	6.2	1.4	1.1	3.8	0.57
V14	37	74	31	5.0	1.0	0.8	3.0	0.50
W1	38	81	33	5.4	1.1	0.8	3.1	0.49
W2	36	83	29	5.3	1.2	0.7	2.8	0.40
W3	42	95	33	6.2	1.3	1.0	3.6	0.55
W4	42	88	37	6.0	1.2	1.0	3.5	0.55
W5	45	96	40	7.3	1.5	1.1	4.3	0.65
W6	37	74	27	5.5	1.3	0.8	3.5	0.55
W7	41	110	33	6.1	1.3	1.0	3.6	0.50
W8	36	77	27	5.2	1.1	0.8	3.2	0.48
W9	41	91	35	6.1	1.4	1.1	3.4	0.55
W10	34	79	27	5.0	1.1	0.8	3.3	0.51
W11	32	62	21	4.5	1.0	0.8	3.0	0.47
W12	34	71	29	4.9	1.1	0.7	3.0	0.48
W13	32	67	26	4.7	1.0	0.6	2.9	0.46
W14	38	76	30	5.9	1.3	0.9	3.8	0.56

ATOMIC ABSORPTION DATA

SAMPLE	CU PPM	PB PPM	ZN PPM	MN PPM	FE %	CO PPM	NI PPM	AG PPM
A1	16.5	21.0	43.9	490.5	2.3	16.0	37.5	0.7
A1a	56.8	49.0	78.2	1099.7	3.0	36.3	47.3	0.3
A2	19.1	24.5	59.2	427.2	2.4	16.0	35.7	0.3
A3	26.3	35.0	66.8	925.6	2.8	20.3	41.1	0.3
A4	23.8	24.5	64.9	577.5	2.9	17.7	35.7	0.3
A5	23.2	28.0	61.1	680.4	2.9	19.4	42.9	0.7
A6	23.8	24.5	55.3	490.5	2.8	19.4	50.9	0.7
A7	24.3	31.5	68.7	530.1	2.9	22.8	74.1	1.0
A8	23.8	38.5	55.3	363.9	2.8	26.2	66.1	1.0
A9	43.4	42.0	78.2	395.6	3.8	38.0	114.3	1.4
A10	17.6	28.0	66.8	886.1	2.9	21.1	65.2	1.0
A11	23.2	31.5	66.8	751.6	2.9	22.8	55.4	0.7
A12	22.7	28.0	64.9	601.3	2.9	22.0	41.1	0.7
A13-1	33.6	28.0	72.5	625.0	3.2	24.5	38.4	0.7
A13-2	27.9	28.0	60.2	553.8	3.1	22.0	46.4	0.7
A14	17.0	31.5	61.1	609.2	3.1	21.1	32.1	1.0
B1	23.2	42.0	70.6	759.5	3.3	22.8	33.9	0.7
B2	24.8	31.5	70.6	403.5	3.0	21.1	51.8	0.7
B3	16.1	25.2	70.1	343.4	3.1	16.8	27.2	1.0
B4	27.2	25.2	81.4	367.4	4.0	29.4	58.9	1.3
B5	22.7	21.6	77.6	471.2	3.5	22.6	41.7	1.0
B6	15.1	18.0	49.2	439.3	2.7	15.9	33.5	1.0
B7	47.4	36.0	73.9	710.9	3.9	36.1	123.2	1.7
B8	43.4	39.6	68.2	782.8	3.7	33.6	107.8	1.3
B9	37.8	36.0	66.3	375.4	3.7	32.7	96.0	1.3
B10	29.7	28.8	73.9	511.2	3.2	22.6	68.8	1.3
B11	28.2	32.4	62.5	862.6	3.4	27.7	75.2	1.0
B12	16.6	21.6	70.1	287.5	3.0	17.6	37.1	1.0
B13	19.2	21.6	63.4	379.4	3.0	18.9	45.8	0.7
B14	35.3	32.4	106.1	495.2	3.9	27.7	75.2	1.7
C1	36.3	43.2	109.8	327.5	3.1	19.3	48.0	0.7
C1.5	31.4	24.8	64.3	804.1	3.1	21.4	48.9	0.7
C2	22.2	21.6	54.9	631.0	2.9	19.3	41.7	0.7
C3	20.2	21.6	56.8	471.2	2.7	19.3	41.7	0.7

SAMPLE	CU PPM	PB PPM	ZN PPM	MN PPM	FE %	CO PPM	NI PPM	AG PPM
C4	36.8	39.6	81.4	1270.0	4.0	34.4	73.4	1.7
C5	15.6	21.6	81.4	231.6	2.7	16.8	40.8	1.0
C6	19.7	21.6	79.5	327.5	3.3	20.1	43.5	1.0
C7	24.3	24.8	62.5	398.1	2.9	20.6	49.8	1.3
C8-1	21.3	21.3	57.0	318.5	2.7	18.9	44.4	1.0
C8-2	17.7	21.3	62.5	342.4	3.1	16.4	32.6	1.0
C9	22.3	28.4	57.0	374.2	2.9	21.4	68.8	1.3
C10	12.2	24.8	88.2	151.3	3.0	14.8	29.9	1.0
C11	12.6	17.7	49.6	191.1	2.3	14.0	33.5	0.7
C12	27.3	24.8	55.1	875.8	3.0	23.8	54.4	0.7
C13	25.8	24.8	76.2	406.0	3.2	20.6	53.8	1.0
C14	25.8	24.8	75.4	390.1	3.1	21.4	54.5	0.7
D1	29.4	21.3	69.8	254.8	2.7	17.3	42.6	0.7
D2	33.9	24.8	128.7	636.9	3.5	27.1	69.8	1.0
D3	32.4	21.3	53.3	366.2	2.9	18.9	39.0	0.7
D4	20.2	24.8	82.7	215.0	3.2	14.8	33.5	0.7
D5	20.8	21.3	71.7	502.0	2.9	21.4	40.8	0.7
D6	16.7	21.3	86.4	422.0	2.9	16.4	36.2	1.0
D7	21.3	31.9	64.3	318.5	3.2	19.7	42.6	0.7
D8	21.8	21.3	75.4	334.4	3.1	18.9	37.1	0.7
D9	44.5	42.9	72.2	725.8	3.7	30.4	83.3	1.3
D10	26.8	25.0	85.2	379.0	3.0	21.7	59.8	1.0
D11	16.7	25.0	55.6	290.3	2.6	19.1	39.9	0.7
D12	19.7	25.0	63.0	274.2	2.7	17.4	42.6	0.7
D13	24.8	39.3	138.9	1040.3	4.1	24.3	26.3	1.0
D14	16.7	21.4	50.0	540.3	2.6	19.1	35.3	0.7
E1	25.8	21.4	55.6	661.3	2.8	20.8	40.8	0.7
E2	30.4	21.4	64.8	403.2	2.7	19.1	41.7	0.7
E2H	10.6	17.9	55.6	201.6	2.3	10.4	19.0	0.7
E3	60.2	25.0	63.0	790.3	3.2	9.6	48.0	0.7
E4	30.4	19.6	63.0	633.0	3.1	20.4	46.2	1.0
E5	21.3	21.4	81.5	1145.2	3.2	22.6	48.9	0.7
E6	10.6	14.3	48.2	193.6	2.3	11.3	27.2	0.7
E7	19.7	21.4	74.1	346.8	3.1	19.1	36.2	0.7
E8	21.8	25.0	92.6	411.3	3.3	21.7	39.9	0.7

SAMPLE	CU PPM	PB PPM	ZN PPM	MN PPM	FE %	CO PPM	NI PPM	AG PPM
E9	16.2	21.4	63.0	298.4	2.8	17.4	38.0	0.7
E10	23.8	21.4	64.8	290.3	2.9	18.2	48.0	1.0
E11	16.7	25.0	57.4	233.9	3.0	22.6	70.6	1.0
E12	16.2	21.6	51.1	246.0	2.1	13.8	34.2	0.7
E13	23.3	21.6	51.1	349.2	2.5	17.2	37.8	0.7
E14	19.2	21.6	47.4	555.6	2.4	18.1	36.0	0.7
F1	24.3	21.6	100.4	325.4	2.8	25.9	52.2	1.0
F2	26.8	25.2	73.0	246.0	2.9	18.1	48.6	1.0
F3	17.2	21.6	49.3	587.3	2.6	19.8	48.6	0.7
F4	18.2	18.0	62.0	325.4	2.6	15.5	38.7	0.7
F5	23.3	21.6	67.5	365.1	2.8	18.1	45.0	0.7
F6	19.2	18.0	43.8	198.4	2.4	12.1	25.2	0.7
F7	22.3	21.6	65.7	325.4	2.7	17.2	42.3	0.7
F8	25.8	21.6	60.2	476.2	3.0	19.0	40.5	0.7
F9	14.2	25.2	63.9	254.0	2.5	14.7	30.6	0.7
F10	11.6	18.0	67.5	142.9	1.9	11.2	27.9	1.0
F11	19.7	21.6	49.3	261.9	2.4	14.7	27.0	0.7
F12	16.7	21.6	51.1	309.5	2.7	17.2	32.4	0.7
F13	19.2	28.8	51.1	444.4	2.8	22.4	62.0	1.0
F14-C1	14.2	14.4	40.2	254.0	2.1	13.8	31.5	0.7
F14-C2	13.2	14.4	36.5	452.4	1.8	12.5	27.4	0.3
G1	25.0	21.6	53.3	548.4	3.0	20.0	48.0	2.4
G2	21.4	25.2	99.3	266.1	3.2	19.1	48.9	1.0
G3	19.4	25.2	49.6	532.3	2.5	16.5	43.5	0.7
G4	24.0	21.6	58.8	854.8	2.8	20.8	47.1	1.0
G5	24.5	25.2	77.2	419.4	2.8	19.1	47.1	1.0
G6	19.4	14.4	46.0	338.7	2.1	13.0	34.4	0.7
G7	28.6	21.6	69.8	685.5	2.8	19.1	40.8	0.7
G8	21.4	25.2	69.8	379.0	3.2	17.4	36.2	1.0
G9	19.9	25.2	60.7	290.3	2.6	17.4	38.0	1.0
G10	21.9	21.6	46.0	217.7	2.5	13.9	29.0	1.0
G11	19.9	25.2	80.9	282.3	2.4	15.6	29.9	1.0
G12	18.9	25.2	62.5	330.6	2.5	15.6	33.5	0.7
G13	18.4	32.4	57.0	225.8	2.7	15.6	35.3	1.4
G14	18.4	25.2	62.5	750.0	2.5	16.5	31.7	0.7

SAMPLE	CU PPM	PB PPM	ZN PPM	MN PPM	FE %	CO PPM	NI PPM	AG PPM
H1	12.2	14.4	39.5	266.2	2.1	12.2	30.8	0.3
H2	19.9	21.6	49.6	354.8	2.7	19.1	38.0	0.7
H3	28.6	25.2	66.2	371.0	3.0	20.0	48.9	0.7
H4	17.9	18.0	46.0	233.9	2.5	15.6	36.2	0.3
H5	19.7	14.2	45.0	229.4	2.3	13.0	36.0	0.7
H6	14.0	17.7	64.8	387.7	2.7	13.9	31.5	1.0
H7	15.0	17.7	54.0	245.2	2.7	11.3	27.9	0.7
H8	22.3	17.7	50.4	363.9	2.4	14.8	36.0	0.7
H9	32.2	17.7	75.5	767.4	3.1	23.4	45.9	0.7
H10	25.4	28.4	86.3	435.1	3.3	20.0	44.1	1.0
H11	21.3	21.3	64.8	356.0	3.0	15.6	37.8	0.7
H12	22.8	24.8	86.3	379.8	3.0	18.2	41.4	1.0
H13	20.2	21.3	63.0	379.8	2.8	14.8	37.8	0.7
H14	21.8	24.8	70.1	419.3	2.7	16.5	36.0	0.7
K1	14.0	14.2	55.8	284.8	2.4	13.0	38.7	0.7
K2	16.6	17.7	45.0	229.4	2.3	12.2	31.5	0.7
K3	30.1	21.3	61.2	672.5	3.0	20.0	49.5	0.7
K4	35.3	24.8	66.6	767.4	3.3	23.4	53.1	0.7
K5A	23.9	21.3	52.2	435.1	2.8	16.5	40.5	0.7
K5B	15.0	17.7	59.4	213.6	2.9	14.8	35.1	1.0
K6	26.4	21.3	55.8	577.5	2.7	18.2	40.5	0.3
K7	24.9	21.3	61.2	348.1	2.7	16.0	41.4	0.7
K8	30.1	24.8	68.4	696.2	3.1	20.0	45.9	0.7
K9	23.7	21.7	54.4	431.0	2.8	18.8	40.4	1.0
K10	25.7	21.7	56.2	736.7	2.8	20.6	45.0	0.7
K11	18.5	21.7	50.7	352.7	2.5	16.3	44.1	0.7
K12	24.2	21.7	67.0	431.0	2.8	17.1	41.4	0.7
K13	18.0	21.7	61.6	305.6	2.7	16.3	36.8	1.0
K14	25.2	21.7	58.0	627.0	2.8	19.7	41.4	0.7
L1	20.1	21.7	59.8	407.5	2.7	18.0	45.0	0.7
L1B	25.7	25.4	70.6	862.1	3.2	22.3	48.8	0.7
L2	21.6	25.4	58.0	579.9	2.7	18.8	38.6	0.7
L3	31.6	23.6	48.9	654.4	2.8	18.8	42.8	0.3
L4	13.9	32.6	63.4	156.7	4.8	15.4	21.1	1.4
L5	65.8	39.8	92.4	760.2	3.2	23.1	45.0	1.0

SAMPLE	CU PPM	PB PPM	ZN PPM	MN PPM	FE %	CO PPM	NI PPM	AG PPM
L6	20.1	25.4	48.9	877.7	2.0	12.8	28.0	0.3
L7	19.0	25.4	50.7	421.0	2.0	15.4	38.6	0.7
L8	12.9	21.7	50.7	274.3	2.4	11.1	26.6	1.0
L9	7.7	18.1	47.1	180.2	2.2	11.1	29.4	0.7
L10	25.7	25.4	54.4	815.0	2.7	18.0	37.7	0.7
L11	38.6	25.4	65.2	1011.0	3.1	21.4	49.6	0.7
L12	30.0	25.9	59.1	632.1	3.0	18.6	42.0	0.7
L13	17.0	18.5	51.2	254.7	2.3	13.5	35.6	0.7
L14	28.9	25.9	68.9	745.3	3.3	20.3	46.5	0.3
L14A	22.2	25.9	55.1	283.0	4.3	16.0	35.6	0.3
M1	19.6	18.5	37.4	358.5	2.2	13.5	35.6	0.7
M2	22.2	22.2	47.2	500.0	2.7	16.0	38.3	0.3
M3	20.7	22.2	49.2	566.0	2.6	16.9	35.6	0.3
M4	24.3	25.9	70.9	405.7	2.8	16.0	34.7	0.7
M5	20.7	18.5	61.0	367.9	2.8	16.9	39.2	0.3
M6	17.6	22.2	76.8	330.2	3.6	22.8	42.0	0.7
M7	76.4	44.4	68.9	1320.8	3.7	27.9	43.8	0.3
M8	24.8	22.2	45.3	594.3	2.7	16.9	34.7	0.3
M9	17.6	14.8	49.2	226.4	2.7	15.2	34.7	0.3
M10	18.1	14.8	45.3	188.7	2.3	12.7	28.3	0.3
M11	23.8	14.8	61.0	94.3	2.0	10.1	16.4	0.7
M12	20.7	25.9	90.6	349.1	3.1	17.7	35.6	0.7
M13	26.3	18.5	61.0	632.1	3.1	20.3	44.7	0.3
M14	33.0	18.5	54.2	462.3	3.0	19.4	36.5	0.3
N1	22.0	14.9	51.2	925.2	2.7	15.8	38.3	0.7
N2	29.7	18.7	74.8	535.0	3.5	21.7	58.4	0.7
N3	26.1	18.7	55.1	632.3	3.0	19.2	45.6	0.3
N4	24.1	18.7	38.2	680.9	2.6	16.7	33.8	0.3
N5	19.0	18.7	43.3	359.9	2.4	15.0	31.9	0.3
N6	19.0	14.9	39.4	466.9	2.3	13.3	31.0	0.3
N7	15.9	22.4	78.7	272.4	2.8	15.0	33.8	0.7
N8	32.3	18.7	49.2	1537.0	2.5	22.5	38.3	0.3
N9	12.3	18.7	61.0	233.5	2.5	13.3	31.9	0.7
N9A	3.1	18.7	5.9	19.5	0.2	0.8	3.6	0.3
N10	22.0	14.9	41.3	262.6	2.5	13.3	31.0	0.3

SAMPLE	CU PPM	PB PPM	ZN PPM	MN PPM	FE %	CO PPM	NI PPM	AG PPM
N11	19.0	18.7	47.2	428.0	2.5	14.2	34.7	0.3
N12	19.0	11.2	41.3	243.2	2.4	12.5	31.9	0.3
N13	31.2	26.1	66.9	2120.6	3.0	22.5	38.3	0.3
N14	26.6	14.9	45.3	710.1	2.5	16.7	35.6	0.3
P1	16.9	11.2	51.2	398.8	2.7	15.8	40.2	0.3
P2	33.8	18.7	65.0	583.7	3.2	31.7	57.5	0.3
P3	20.5	14.9	45.3	593.4	2.6	16.7	37.4	0.3
P4	17.3	22.7	56.2	212.4	3.0	14.2	30.3	1.3
P5	12.2	18.9	71.7	193.0	2.3	12.5	28.5	1.3
P7	20.3	22.7	48.4	299.2	2.3	13.3	30.3	0.6
P8	20.3	18.9	42.6	386.1	2.1	14.2	29.4	0.6
P9	20.8	15.2	75.6	231.7	2.6	13.3	28.5	0.6
P10	24.4	49.2	31.0	1196.9	3.0	32.5	29.4	1.6
P11	68.6	45.4	52.3	704.6	3.3	20.0	39.5	1.0
P12	22.9	22.7	46.5	530.9	2.5	15.8	34.9	0.6
P13	15.2	18.9	69.8	405.4	2.5	13.3	34.0	0.6
P14	21.8	15.2	54.3	386.1	2.6	15.0	38.6	0.6
Q1	23.9	22.7	65.0	289.6	3.2	19.6	45.5	1.0
Q2	24.4	22.7	60.1	675.7	3.2	20.0	46.9	0.6
Q3	20.3	15.2	48.4	521.2	2.8	15.8	43.2	0.6
Q4	17.3	15.2	58.1	366.8	2.6	15.0	47.8	0.6
Q5	15.2	15.2	71.7	579.2	2.6	13.3	36.8	0.6
Q6	20.3	18.9	62.0	974.9	2.8	14.2	34.0	0.6
Q7	15.2	18.9	54.3	318.5	2.3	10.8	26.6	0.6
Q9	17.8	15.2	44.6	289.6	2.4	13.3	36.8	0.6
Q10	18.3	18.9	52.3	444.0	2.8	15.0	32.2	0.6
Q11	16.4	22.9	46.6	398.8	2.3	14.4	28.7	0.7
Q12	19.5	19.1	44.8	369.6	2.4	15.2	33.3	0.7
Q13	15.9	15.3	48.5	389.1	2.4	15.2	34.3	0.3
Q14	40.0	34.4	46.6	1050.6	2.9	24.5	38.9	0.7
R1	23.6	22.9	50.4	642.0	3.0	20.3	49.1	0.7
R2	21.0	19.1	110.1	1216.0	3.5	30.4	55.6	0.7
R3	24.1	22.9	63.4	428.0	3.2	22.0	52.8	0.7
R4	27.7	61.2	89.6	398.8	2.8	20.3	49.1	0.7
R5	35.4	15.3	54.1	398.8	2.8	16.0	45.4	0.3

SAMPLE	CU PPM	PB PPM	ZN PPM	MN PPM	FE %	CO PPM	NI PPM	AG PPM
R6	17.4	15.3	46.6	428.0	2.4	16.0	38.0	0.3
R7	21.5	15.3	52.2	583.7	2.8	17.7	46.3	0.3
R9	13.3	11.4	35.4	262.6	2.1	12.7	35.2	0.3
R10	29.2	19.1	57.8	651.8	3.1	19.4	50.0	0.3
R11	14.3	15.3	42.9	272.4	2.5	13.5	37.0	0.7
R12	18.4	19.1	72.8	194.6	2.9	16.0	42.6	0.3
R13	12.8	15.3	49.4	165.4	2.3	11.0	29.6	0.3
R14	38.4	26.7	56.0	282.1	3.8	21.1	38.9	0.3
S2	24.1	23.1	55.3	625.0	2.9	20.4	44.7	1.0
S3	20.5	19.2	55.3	519.2	2.9	17.9	42.0	0.7
S4	23.6	23.1	59.2	605.8	2.9	18.7	42.0	0.7
S5	16.4	15.4	53.4	298.1	2.6	14.5	33.8	0.7
S6	17.9	19.2	45.8	413.5	2.6	15.3	38.3	0.7
S7	12.3	15.4	40.1	230.8	2.4	11.9	23.7	0.7
S8	17.4	15.4	45.8	384.6	2.5	14.5	35.6	0.7
S9-2	21.0	15.4	40.1	519.2	2.3	14.5	29.2	0.3
S10	12.8	15.4	38.2	211.5	1.8	10.2	22.8	0.3
S11	16.4	15.4	47.7	173.1	2.5	12.8	28.3	0.3
S12	18.4	19.2	43.9	192.3	2.3	11.9	32.8	0.7
S13	23.6	19.2	49.6	182.7	2.7	17.0	44.7	0.7
S14	15.4	15.4	53.4	105.8	2.2	12.8	41.1	0.7
T2	31.8	26.9	76.3	692.3	3.6	20.4	42.9	0.7
T3	19.5	15.4	55.3	461.5	2.6	14.5	36.5	0.7
T4	24.6	23.1	53.4	634.6	2.8	17.9	38.3	0.7
T5	19.5	15.4	55.3	500.0	2.8	15.3	40.2	0.7
T6	17.9	15.4	57.2	278.8	2.8	15.3	39.2	0.7
T7	22.5	19.2	49.6	471.2	3.0	17.0	42.9	0.7
T8	18.4	15.4	49.6	307.7	2.5	14.5	35.6	0.7
T9	20.8	15.2	34.9	285.8	2.1	13.7	35.6	0.7
T10	14.8	15.2	48.4	271.3	2.3	14.6	34.7	0.7
T11	20.0	15.2	46.5	387.6	2.5	16.3	34.7	0.7
T12	20.0	15.2	44.6	649.2	2.5	18.0	37.4	0.7
T13	14.2	18.9	42.6	203.5	2.2	12.8	31.9	0.7
T14	21.1	15.2	42.6	281.0	2.3	15.4	38.3	0.7
V1	24.8	18.9	67.8	319.8	2.8	19.7	42.0	1.0

SAMPLE	CU PPM	PB PPM	ZN PPM	MN PPM	FE %	CO PPM	NI PPM	AG PPM
V2	25.3	18.9	62.0	542.6	3.0	19.7	38.3	1.0
V3	34.8	22.7	67.8	746.1	3.5	23.1	42.0	1.0
V4	25.3	18.9	62.0	581.4	3.0	20.6	33.8	1.0
V5	20.0	22.7	50.4	629.8	2.6	18.8	31.9	1.0
V6	31.1	26.5	69.9	765.5	3.4	21.4	44.7	1.0
V7	22.7	22.7	52.3	591.1	2.8	19.7	37.4	0.7
V7.5	32.2	22.7	73.6	804.3	3.4	23.1	62.0	1.0
V8	9.0	11.4	40.7	155.0	2.0	9.4	20.1	0.7
V9	14.2	18.9	75.6	222.9	3.1	14.6	42.9	0.7
V10	15.3	15.2	54.3	494.2	2.3	16.3	32.8	1.0
V12	16.9	15.2	42.6	300.4	2.5	14.6	34.7	0.7
V14	8.8	11.4	32.4	178.6	2.1	12.2	27.0	1.0
W1	25.4	19.1	57.2	453.7	3.0	18.6	43.8	0.7
W2	29.6	15.3	59.2	617.8	2.9	19.4	43.8	0.7
W3	20.2	15.3	47.7	482.6	2.5	16.0	37.4	0.7
W4	20.8	15.3	55.3	434.4	2.7	16.0	37.4	0.7
W5	27.0	19.1	53.4	627.4	2.8	20.3	43.8	0.7
W6	20.2	11.4	43.9	328.2	2.6	13.5	41.1	0.7
W7	23.3	22.9	51.5	781.8	2.9	21.1	42.0	1.0
W8	14.5	15.3	55.3	241.3	2.5	12.7	26.5	0.7
W9	25.9	19.1	55.3	723.9	2.9	20.3	41.1	0.7
W10	23.9	15.3	51.5	1003.9	2.7	19.4	47.4	0.7
W11	13.5	11.4	34.4	231.7	2.4	13.5	33.8	0.7
W12	20.2	15.3	45.8	405.4	2.4	16.0	36.5	0.7
W13	16.8	7.6	36.3	516.4	2.2	13.5	28.8	0.7
W14	16.6	11.4	42.0	357.1	2.3	13.5	31.9	0.7

VITAE

Candidate's full name:	Solweig Anita Balzer
Place and date of birth:	Kitchener, Ontario March 1, 1965
Permanent address:	57 Waldau Crescent Kitchener, Ontario
Schools attended (with dates):	Waterloo Oxford District Secondary 1979-1984
Universities attended with dates and degrees obtained:	University of Waterloo 1984-1989 B.Sc. (Hon.) Co-op Applied Earth Sciences

Publications:

BALZER, S.A. 1991. Quaternary geology and dispersal patterns of the Canterbury map area (N.T.S. 21 G/14), York County, New Brunswick. In Project Summaries for 1991, 16th Annual Review of Activities. Edited by S.A. Abbott. New Brunswick Department of Natural Resources, Information Circular 91-2, pp. 28-29.

BALZER, S.A. 1990. Quaternary geology of the Canterbury map area (N.T.S. 21 G/14), York County, New Brunswick: preliminary report (PROV). In Project Summaries for 1990, 15th Annual Review of Activities. Edited by S.A. Abbott. New Brunswick Department of Natural Resources, Information Circular 90-2, pp. 44-45.

BALZER, S.A. 1986. Survey of Foreign Offshore Development Activities for Minerals other than Oil and Gas. Government Publication, Canada Oil and Gas Lands Administration.

BALZER, S.A. and BROSTER, B.E. 1991. Glacial dispersion of clast lithologies: Lake George Area, New Brunswick. CANQUA Conference, Program with Abstracts, p.15.

JOSENHANS, H., BALZER, S., HENDERSON, P., NIELSON, E., THORLIEFSON, H. and ZEVENHUISEN, J. 1988. Preliminary seismographic and geomorphic interpretations of the Quaternary sediments of Hudson Bay. In Current Research, Part B, Geological Survey of Canada, Paper 88-11B, p. 271-286.

67°30'

N.T.S. 21 G/14

25'

20'

15'

46°00'

55'

Upper Southampton

Meductic

Dorrington Hill

Charlie Lake

Allandale

Pokiok

Nackaw

Southampton

Gt

Ap

Gx

Cv

Op

$M_{DH}v/R$

$M_{DH}v$

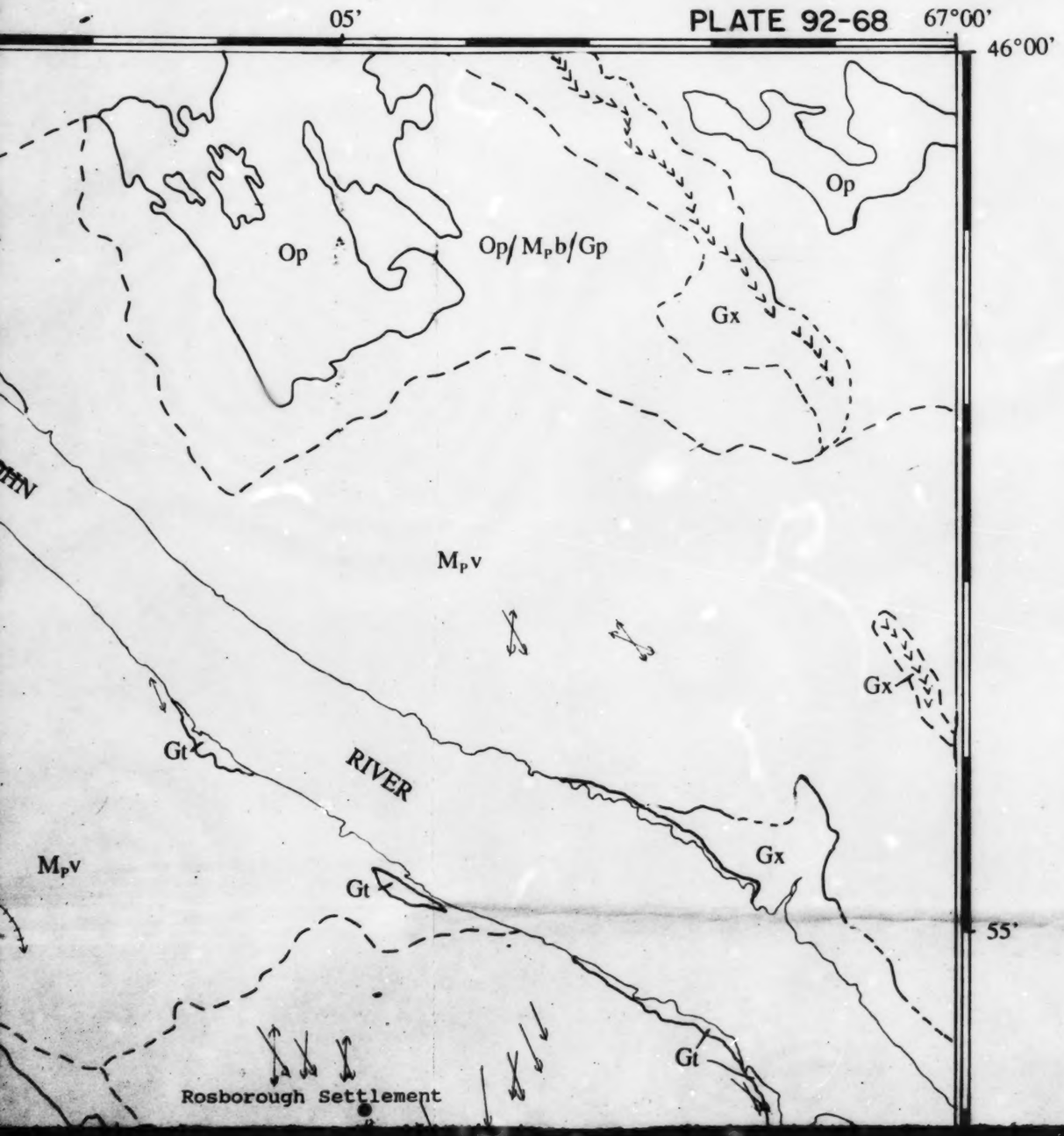
$M_{P}v/R$

New Nouveau
Brunswick

15' 10' 05'

PLATE 92-68 67

Op
Op
Nackawic
Gl
$M_{DH}V$
$M_{DH}V$
Cv
SAINT
Day Hill
Gt
Op
Op/ M_pb/Gp
Op
Gx
M_pV/R
Southampton
Gx
$M_{DH}V$
M_pV
JOHN
Pokiok
Gx
M_pV
M_pV
$M_{DH}V$
Op
Davidson Lake
Gt
RIVER
Gx
M_pb
M_pV
Gt
Gx
M_pV/R
Op
Op
M_pb/Op
Op
Op
M_pb
Op
M_pb/Op
Allandale
Rosborough Settlement
Gt



LEGEND

QUATERNARY

Cv COLLUVIAL SEDIMENTS: veneer of sand, silt, rubble; deposited along flanks of steep valleys.

Ap ALLUVIAL SEDIMENTS: flood plains; sand, gravel, silt; minor clay; variable thickness; deposited as channel, overbank and floodbasin deposits at or near present level.

Op ORGANIC SEDIMENTS: bogs, swamps, peat, muck; minor sand and silt; generally 1 to five metres thick; deposited in shallow basins and poorly drained areas.

LATE WISCONSINAN

GLACIOFLUVIAL SEDIMENTS: gravel, sand, silt, minor clay; deposited at the margin of, within or under retreating glacial ice.

Gp Gt Outwash: sand, gravel, minor silt and clay;
Gp - plains and valley trains; thickness >2 metres
Gt - terraces; modified by river action

Gl Gx Ice-contact deposits: sand, gravel, minor silt and till;
Gl - kame-delta complexes; thickness >5 metres
Gx - eskers, kames, outwash plains complexes

MORAINAL DEPOSITS: basal and ablation till, and boulder lags; minor reworking by water.

M_{DH} Dorrington Hill Member: silty till with rare surface boulders; some sand and clay; generally <2 metres thick, some exceptions; streamlined topography, and rolling hills;
$M_{DH}V$ - veneer of basal till (<2 metres thick); minor ablation till

Canterbury ●

Allandale ●

Lake

Shogomoc Lake

Flat Top Mt.

Grassy Lake

Kilburn Lake

Cranberry Ridge

50'

$M_{DH}v/R$

M_pv/R

M_pvr

M_pv

$M_{DH}v$

M_pb/Op

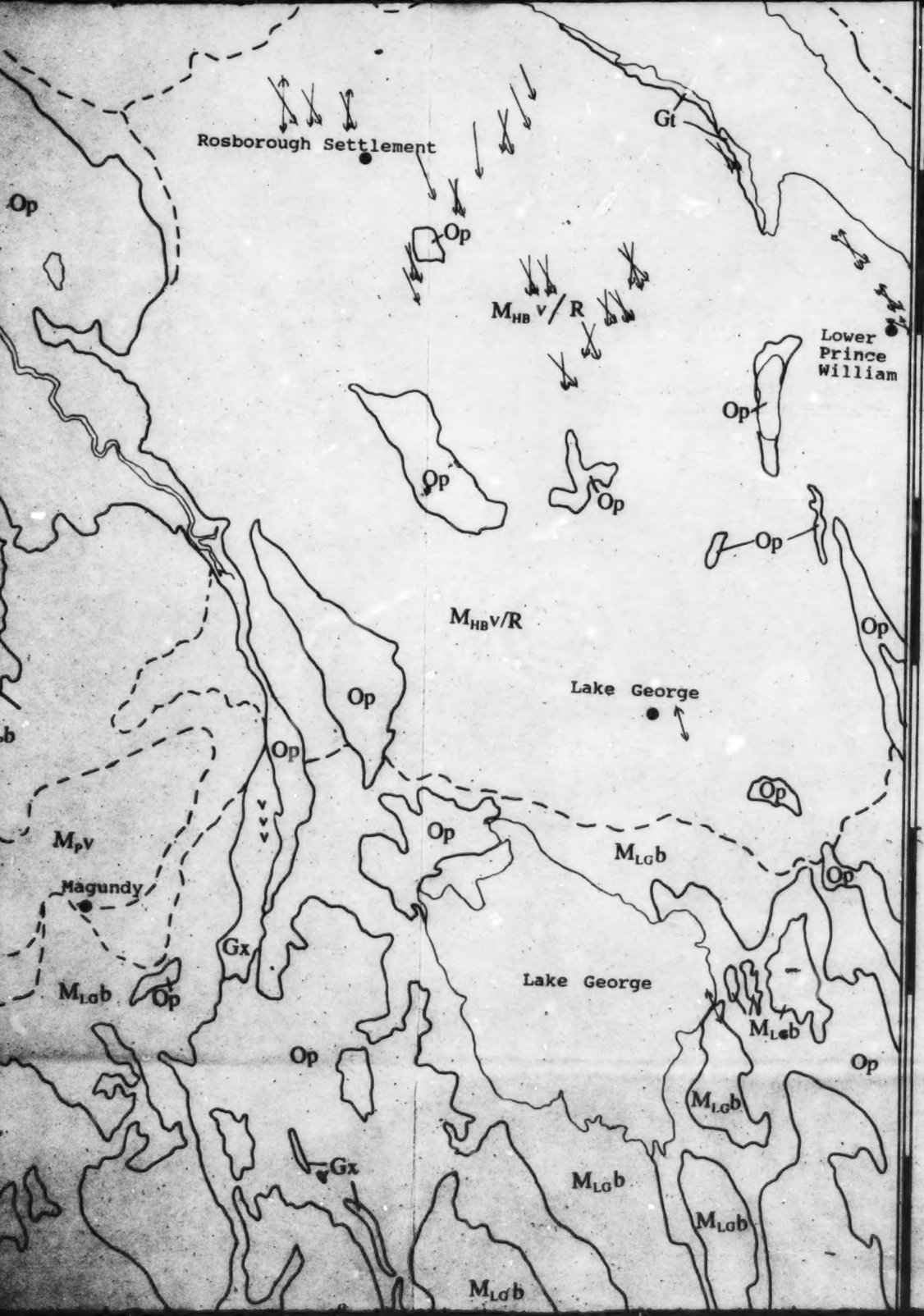
M_pb

Op

Gx

Gp

Allandale
Rosborough Settlement
Gt
Flat Top Mt.
Mud Lake
Magundy
Blaney Ridge
Lake George
Little Magaguadavic Lake
Lake
Op
Gx
M_pb
M_pb/Op
M_pv
M_pv/R
$M_{HB}v/R$
$M_{LG}b$
$M_{LG}b$



50'

MORAINAL DEPOSITS: basal and ablation till, and boulder lags; minor reworking by water.

M_{DH} Dorrington Hill Member: silty till with rare surface boulders; some sand and clay; generally <2 metres thick, some exceptions; streamlined topography, and rolling hills;
M_{DH}v - veneer of basal till (<2 metres thick); minor ablation till
M_{DH}v/R - veneer of till with bedrock near surface and commonly outcropping.

M_p Pokiok Member: sandy till, abundant surface boulders; variable thickness; often grades into grus;
M_pv - veneer of basal till (<1.5 metres thick); minor ablation till
$M_p$vr - veneer of till overlying grus; forms elongated ridges
M_pv/R - veneer of till with bedrock near surface and commonly outcropping
M_pb - blanket of basal till, ablation till; boulder lags up to 90% of surface coverage

M_{LG} Lake George Member: silty till, very mottled; rare surface boulders; forms thick blankets (>2 metres); very flat topography; swamps common
M_{LG}b - blanket of basal till; mottled colouring

M_{HB} Hammond Brook Member: sandy to silty till; forms a veneer (<1 metre thick); small bedrock outcrops are common
M_{HB}v/R - veneer of basal till (<1 metre thick); bedrock common

PRE-QUATERNARY

R BEDROCK: various lithologies and ages; generally weathered and partially disintegrated; glacially streamlined and scoured surfaces.

Geological boundary (defined, approximate) .....
Esker .....
Meltwater channel .....
Drumlinoid ridge, glacial fluting .....

Gp
Op
Grassy Lake
Op
$M_{DH}v/R$
Op
Op
Cranberry Ridge
M_pv/R
M_pv
Gp
Op
M_pv/R
Op
M_pb
Op
M_pv
M_pb
Op
Op
Gx
Op
Kilburn Lake
Op
M_pv/R
Op
M_pb
Op
Op
Op
M_pb
M_pv
Op
M_pb
Op
M_pb
Op
M_pb
Op
M_pv
M_pv
Op
M_pv/R
45°45'
67°30'
25'
20'
15'

SURFICIAL GEOLOGY OF THE CANTERBURY (21G/14) M

SCALE 1:50 000

1 0 1 2

Kilometres

Mud Lake

Magundy

Lake George

Little Magaguadavic Lake

Blaney Ridge

Magaguadavic Lake

Magaguadavic

Harvey Lake

15'

10'

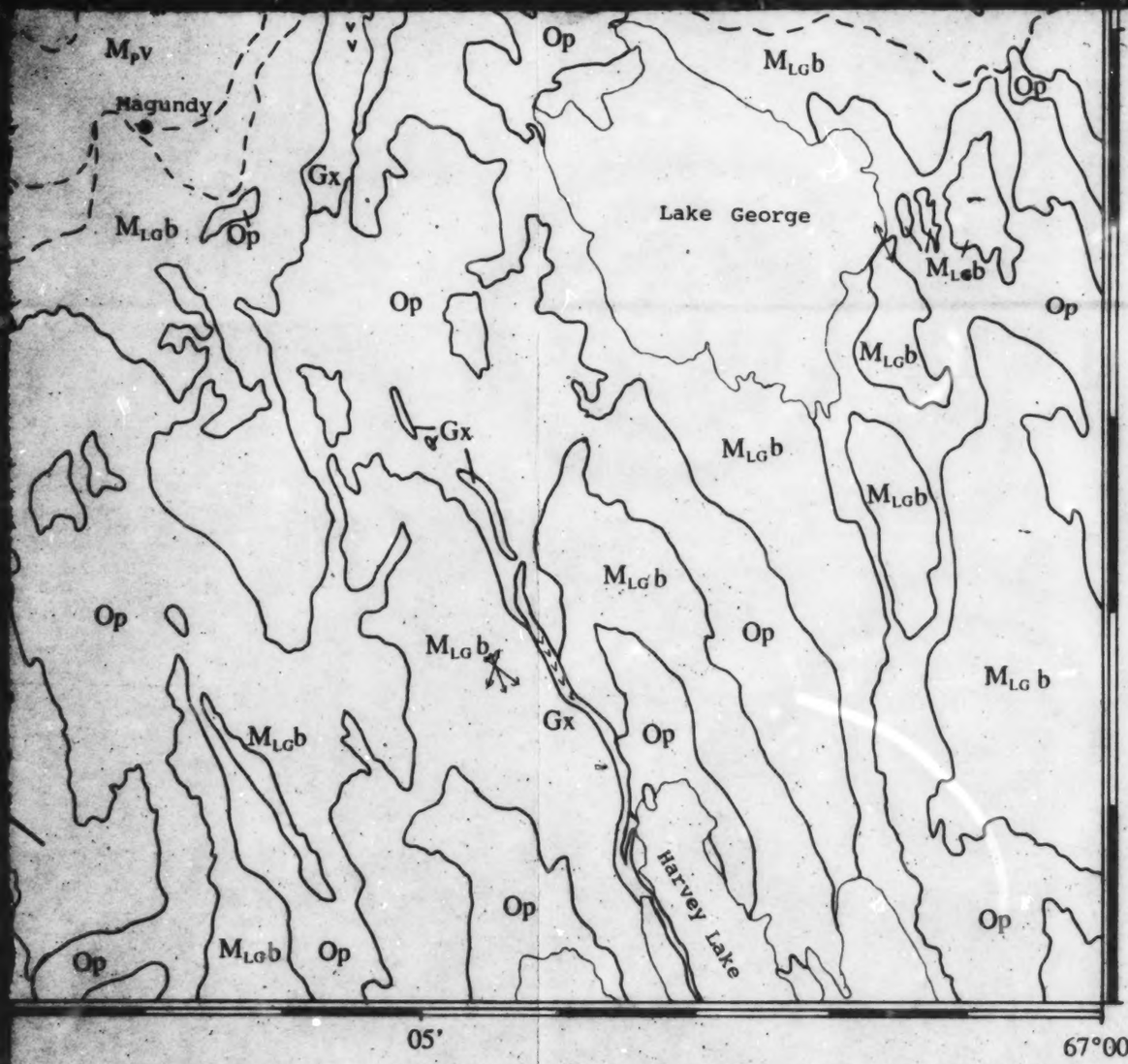
05'

GY OF THE CANTERBURY (21G/14) MAP AREA, NEW BRUNSWICK

SCALE 1:50 000

1 0 1 2 3 4

Kilometres



50'

PRE-QUATERNARY

R BEDROCK: various lithologies and ages; generally weathered and partially disintegrated; glacially streamlined and scoured surfaces.

Geological boundary (defined, approximate) .....

Esker .....

Meltwater channel .....

Drumlinoid ridge, glacial fluting .....

Striae (direction known, unknown) .....

Settlement, Town .....

Geology by S.A. Balzer, 1990-1991
University of New Brunswick

This report should be referenced in the following manner:

BALZER, S.A., 1992. Surficial geology of the Canterbury (21 G/14) map area, New Brunswick. New Brunswick Department of Natural Resources and Energy, Mineral Resources, Plate 92-68

To accompany Open File Report 92-9.